

Spacelab Level IV Programmatic Implementation Assessment Study

FINAL
REPORT

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Volume II

Ground Processing Requirements

PREPARED UNDER CONTRACT NO. NAS1-14909

BY



Rockwell International

Space Division

FOR



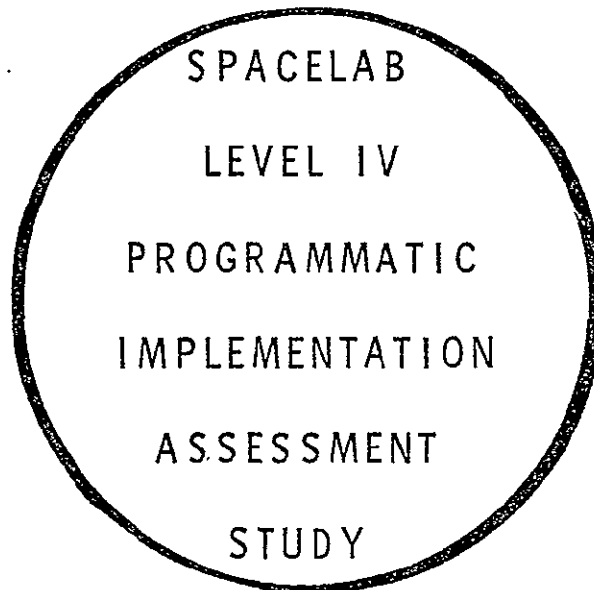
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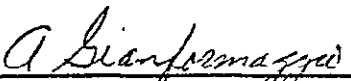
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Volume II

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A. Gianformaggio
Study Manager

PREPARED UNDER CONTRACT NO. NAS1-14909
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FOREWORD

The Spacelab Level IV Programmatic Implementation Assessment Study was conducted to assess the Level IV payload integration requirements. In the study, alternate Level IV integration approaches were synthesized and evaluated to establish the most cost-effective experiment integration approach. Resource requirements or cost factors that were included in the assessment pertained to the "hands-on" activities of ground processing. These requirements included manpower, temporary duty subsistence and air fare, flight hardware and Ground Support Equipment (GSE) transportation costs, and prorated flight hardware and GSE use costs based upon the involvement time of these items for each mission. Programmatic inventories of flight hardware and GSE were developed using representative payloads. These payloads were defined to a level of detail that permitted a detailed assessment of the handling, installation, servicing and checkout requirements of the experiment end items. Spacelab flight hardware and GSE support and interface requirements were identified. Buildup schedules for the inventories were formulated. Alternate ground processing concepts were synthesized and the processing of each of the representative payload through these concepts was evaluated. Cost data for each processing option was developed for each payload. The spectrum of experiments and payloads used in the study facilitated the identification of design characteristics to identify the ground processing activities. Guidelines were identified to assist experimenters in the development of payload designs that will permit cost-effective ground processing.

The results of the Spacelab Level IV Programmatic Implementation Assessment Study effort are presented in four volumes:

VOLUME I	REPRESENTATIVE PAYLOAD DEFINITION	SD 78-SR-0009-1
VOLUME II	GROUND PROCESSING REQUIREMENTS	SD 78-SR-0009-2
VOLUME III	OPTIMIZATION AND PROGRAMMATICS	SD 78-SR-0009-3
VOLUME IV	EXECUTIVE SUMMARY	SD 78-SR-0009-4



CONTENTS

<u>Section</u>		<u>Page</u>
1.0	INTRODUCTION	1-1
2.0	ALTERNATE GROUND PROCESSING OPTIONS	2-1
	DISTRIBUTED SITE OPTIONS	2-1
	LEAD CENTER OPTIONS	2-7
	KSC OPTIONS	2-8
	SUMMARY OF GROUND PROCESSING OPTIONS	2-8
	QUALITATIVE ASSESSMENT OF OPTIONS	2-12
3.0	PAYLOAD INSTALLATION AND TEST REQUIREMENTS	3-1
	INTRODUCTION	3-1
	Baseline Concept Development Guidelines	3-1
	Applicable Payload Options	3-2
	Standardized Time Estimations	3-3
	SPACE PROCESSING PAYLOAD INSTALLATION & TEST REQUIREMENTS	3-9
	Applicable Ground Processing Options	3-10
	Installation Requirements	3-10
	Test Requirements Identification	3-14
	Installation and Test Activity Assignment	3-16
	Experiment Installation and Test Sequences	3-17
	Summary	3-17
	COMBINED ASTRONOMY PAYLOAD INSTALLATION & TEST REQUIREMENTS	3-31
	Applicable Ground Processing Options	3-31
	Installation Requirements	3-32
	Test Requirements Identification	3-35
	Assembly Procedure	3-38
	Installation and Test Sequences	3-42
	LIFE SCIENCES PAYLOAD INSTALLATION & TEST REQUIREMENTS	3-59
	Applicable Ground Processing Options	3-62
	Installation/Integration Constraints	3-64
	Ground Processing Equipment Requirements	3-67
	Installation and Test Procedures	3-75
	Experiment Installation and Test Sequences (Waterfalls)	3-96



CONTENTS (Cont'd)

<u>Section</u>		<u>Page</u>
3.0	PAYLOAD INSTALLATION AND TEST REQUIREMENTS (Cont'd)	
	ATL PAYLOAD INSTALLATION & TEST REQUIREMENTS	3-114
	Applicable Ground Processing Options	3-116
	Installation/Integration Constraints	3-117
	Ground Processing Equipment Requirements	3-118
	Installation and Test Procedures	3-121
	Installation and Test Sequences (Waterfalls)	3-133
4.0	LEVEL IV INTEGRATION RESOURCE REQUIREMENTS	4-1
	PERSONNEL REQUIREMENTS	4-1
	Hands-On Personnel Requirements	4-1
	Host Center Support Requirements	4-2
	STS Operations Support	4-2
	Personnel Cost Requirements	4-6
	TEMPORARY RELOCATION REQUIREMENTS (TDY)	4-7
	TRANSPORTATION REQUIREMENTS	4-7
	GSE REQUIREMENTS	4-7
	End Item Usage	4-11
	GSE Requirements Estimates	4-11
	SPACELAB FLIGHT HARDWARE REQUIREMENTS	4-29
	PAYLOAD COST SUMMARIES	4-29
	Space Processing Ground Processing Cost Summary	4-34
	Combined Astronomy Ground Processing Cost Summary	4-35
	Life Sciences Ground Processing Cost Summary	4-36
	ATL Ground Processing Cost Summary	4-37
	Flight Hardware Involvement Time Summary	4-37
APPENDIX	Acronyms and Abbreviations List	A-1



ILLUSTRATIONS

<u>Figure</u>		<u>Page</u>
2-1	Individual Experiment Integration-Level III/II Assembly and Checkout	2-2
2-2	Individual Experiment Integration-Pre-Level III/II Combined Checkout	2-6
2-3	Payload Assembly and Checkout-Disassembly for Transportation	2-9
2-4	Ground Processing Options-Top Level Functional	2-10
2-5	Matrix of Processing Options	2-11
3-1	Structural/Mechanical Task Estimates	3-4
3-2	Cable/Harness Task Estimates	3-5
3-3	Rigid/Fluid Line Task Estimates	3-7
3-4	Verification Task Estimates	3-8
3-5	General Arrangement-Space Processing Payload	3-9
3-6	Orbiter Aft Flight Deck Arrangement-Space Processing Payload	3-11
3-7	Space Processing Payload Illustrated Assembly Sequence	3-19
3-8	Installation and Test Timeline for the Electromagnetic Levitation Melt Facility #1	3-21
3-9	Installation and Test Timeline for the Acoustic Levitation Melt Facility #2	3-22
3-10	Installation and Test Timeline for Multipurpose Furnace Melt Facility #3	3-23
3-11	Installation and Test Timeline for Float Zone Refining/Crystal Growth Melt Facility #4	3-25
3-12	Integrated Space Processing Payload Installation and Test Sequence	3-27
3-13	Space Processing Payload-Level III/II Integration Activities	3-29
3-14	Space Processing Payload-Level I OPF Operations	3-29
3-15	Space Processing Payload-Level IV Deintegration	3-29
3-16	Summary of Space Processing Payload Ground Operations	3-30
3-17	Combined Astronomy Payload	3-31
3-18	Orbiter Aft Flight Deck Arrangement for Combined Astronomy Payload	3-34
3-19	Combined Astronomy Buildup Sequence	3-39
3-20	Forward Complement Installation and Test Sequence	3-43
3-21	Mid-Complement Installation and Test Sequence	3-45
3-22	Aft Complement Installation and Test Sequence	3-47
3-23	Combined Payload Assembly and Checkout Sequence	3-49
3-24	Combined Astronomy-Integrated Payload Assembly and Checkout	3-51
3-25	Combined Astronomy Payload Level III/II Integration	3-53
3-26	Supercritical Helium System Chill, Fill and Top Off	3-54
3-27	Level IV Deintegration - Combined Astronomy	3-55
3-28	Combined Astronomy Ground Processing Flows for Distributed Site Option	3-56



ILLUSTRATIONS (CONT'D)

<u>Figure</u>		<u>Page</u>
3-29	Combined Astronomy Ground Processing Flows for KSC Option	3-57
3-30	Combined Astronomy Ground Processing Flows for Lead Center Option	3-58
3-31	General Arrangement for Life Sciences Payload	3-59
3-32	Spacelab Module Rack Arrangement for Life Sciences Payload	3-60
3-33	Orbiter Aft Flight Deck Arrangement for Life Sciences Payload	3-61
3-34	Life Sciences Ground Processing Scenarios	3-63
3-35	Rack/Floor Site Distribution and Inter-Rack Connections	3-72
3-36	Life Sciences Ground Assembly Flow, Site #1	3-77
3-37	Life Sciences Ground Assembly Flow, Site #2	3-79
3-38	Life Sciences Ground Assembly Flow, Site #3	3-81
3-39	Life Sciences Ground Assembly Flow, Site #4	3-83
3-40	Life Sciences Ground Assembly Flow, Site #5	3-85
3-41	Life Sciences Ground Assembly Flow, Site #6	3-87
3-42	Life Sciences Ground Assembly Flow, Site #7	3-89
3-43	Life Sciences Ground Assembly Flow, Site #8	3-91
3-44	Life Sciences Ground Assembly Flow, Lead Center Assembled Payload	3-93
3-45	Life Sciences Distributed Site #1 Installation & Test Sequence	3-97
3-46	Life Sciences Distributed Site #2 Installation & Test Sequence	3-99
3-47	Life Sciences Distributed Site #3 Installation & Test Sequence	3-100
3-48	Life Sciences Distributed Site #4 Installation & Test Sequence	3-101
3-49	Life Sciences Distributed Site #5 Installation & Test Sequence	3-102
3-50	Life Sciences Distributed Site #6 Installation & Test Sequence	3-103
3-51	Life Sciences Distributed Site #7 Installation & Test Sequence	3-104
3-52	Life Sciences Distributed Site #8 Installation & Test Sequence	3-105
3-53	Life Sciences Integration Sequence for Centralized Site Options B-1, B-3, C-1, C-3.	3-106
3-54	Life Sciences Combined Payload Integration Sequence	3-108
3-55	Life Sciences Deintegration	3-109
3-56	Life Sciences Distributed Site Ground Processing Cycles	3-110
3-57	Life Sciences Payload Lead Center Life Cycle B-1, B-3, B-4 & B-5	3-111
3-58	Life Sciences Payload Total Life Cycle Flow - Lead Center Concept (KSC), C-1, C-3 and C-4	3-113
3-59	General Arrangement - ATL Payload	3-114
3-60	Spacelab Module Arrangement - ATL Payload	3-115
3-61	Orbiter Aft Flight Deck Arrangement - ATL Payload	3-116
3-62	ATL Total Ground Processing Flow	3-123
3-63	ATL Mini-Center #1, Pallet 1, Racks 5 & 6	3-134
3-64	ATL Mini-Center #2, Racks 3A and 3B	3-135
3-65	ATL Mini-Center #3, Pallet 2, Racks 4A and 4B, and Special (SF-2 and ST16B).	3-136
3-66	ATL Lead Center/KSC Processing Flow, Options B-1, B-3, C-1 & C-3	3-137



ILLUSTRATIONS (CONT'D)

<u>Figure</u>		<u>Page</u>
3-67	ATL Lead Center/KSC Processing Flow, Options B-4 and C-4	3-141
3-68	ATL Level IV Deintegration	3-143
3-69	ATL Total Ground Processing Flow Concepts A-1, A-2 and A-3	3-144
3-70	ATL Total Ground Processing Flow Concepts B-1, B-4, B-5	3-145
3-71	ATL Total Ground Processing Flow Concepts C-1, C-4	3-146
4-1	Determination of GSE Involvement Times.	4-12



TABLES

<u>Table</u>		<u>Page</u>
2-1	Individual Experiment-III/II Assembly Functional Descriptions . . .	2-3
2-2	Delta Activities for Individual Experiment Integration - Pre III/II Combined Checkout	2-5
2-3	Qualitative Assessment of Ground Processing Concepts	2-13
3-1	Options Applicable to Each Payload	3-2
3-2	Space Processing Payload End Items	3-12
3-3	Level IV GSE Requirements for Space Processing Payload	3-15
3-4	Combined Astronomy Payload Experiment Equipment	3-33
3-5	Combined Astronomy Payload Spacelab Support Equipment	3-35
3-6	Special Handling, Checkout, Servicing and Auxiliary Ground Equipment	3-36
3-7	Life Sciences Payload Experiment Complement	3-65
3-8	Life Sciences Payload Experiment Equipment Distributed in Spacelab	3-66
3-9	Distributed (Mini) Centers Experiment Installation	3-68
3-10	Life Sciences Equipment Requirements Summary	3-73
3-11	Life Sciences Payload Spacelab Interfacing Equipment	3-73
3-12	Life Sciences Payload GSE Requirements	3-74
3-13	Life Sciences Payload Special Test Equipment	3-74
3-14	Mini-Center Experiment and Spacelab Hardware Distribution	3-118
3-15	Experiment End Item Equipment.	3-119
3-16	Spacelab Unique Flight Hardware	3-119
3-17	Ground Support Equipment	3-120
3-18	Special Test Equipment	3-121
3-19	ATL Experiment Verification Tests	3-125
3-20	Shared Equipments (Experiments and End Item Illustrated)	3-132
4-1	Space Processing Manpower Requirements	4-3
4-2	Combined Astronomy Manpower Requirements.	4-3
4-3	Life Sciences Manpower Requirements	4-3
4-4	ATL Manpower Requirements	4-3
4-5	Space Processing Host Center Support Requirements	4-4
4-6	Combined Astronomy Host Center Support Requirements	4-4
4-7	Life Sciences Host Center Support Requirements	4-4
4-8	ATL Host Center Support Requirements.	4-4
4-9	Space Processing STS Operations Support	4-5
4-10	Combined Astronomy STS Operations Support.	4-5
4-11	Life Sciences STS Operations Support	4-5
4-12	ATL STS Operations Support	4-5
4-13	Space Processing Summary Personnel Costs	4-6
4-14	Combined Astronomy Summary Personnel Costs	4-6
4-15	Life Sciences Summary Personnel Costs	4-6
4-16	ATL Summary Personnel Costs	4-6



TABLES (Cont'd)

<u>Table</u>		<u>Page</u>
4-17	Space Processing TDY Costs	4-8
4-18	Combined Astronomy TDY Costs	4-8
4-19	Life Sciences TDY Costs	4-8
4-20	ATL TDY Costs	4-9
4-21	Space Processing Transportation Requirements	4-9
4-22	Combined Astronomy Transportation Requirements	4-10
4-23	Life Sciences Transportation Requirements	4-10
4-24	ATL Transportation Requirements	4-10
4-25	Space Processing GSE Requirements	4-13
4-26	Combined Astronomy GSE Requirements	4-14
4-27	Life Sciences GSE Requirements	4-18
4-28	ATL GSE Requirements	4-26
4-29	Space Processing Flight Hardware Requirements	4-30
4-30	Combined Astronomy Flight Hardware Requirements	4-30
4-31	Life Sciences Flight Hardware Requirements	4-31
4-32	ATL Spacelab Flight Hardware Requirements	4-32
4-33	Space Processing Ground Processing Costs	4-34
4-34	Combined Astronomy Ground Processing Costs	4-35
4-35	Life Sciences Ground Processing Costs	4-36
4-36	ATL Ground Processing Costs	4-37
4-37	Flight Hardware Involvement Time Summary (Working Days)	4-38

1.0 INTRODUCTION



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In order to provide a broad spectrum of Level IV integration ground processing requirements, four types of Spacelab payloads were analyzed in this study. These payloads are considered to be representative of the Spacelab traffic model. The payloads analyzed were:

- | | |
|-----------------------------------|--|
| 1. Space Processing. | A single pallet payload that is representative of materials development and industrial applications activities, which would be part of a mixed cargo Orbiter flight. |
| 2. Combined Astronomy. | A five pallet payload that is representative of astrophysics, solar terrestrial, and astronomy investigations. |
| 3. Life Sciences. | A long module payload that is representative of aerospace bioscience and physiological investigations. |
| 4. Advanced Technology Laboratory | A short module plus pallet train payload that is representative of multi-disciplined technological investigations. |

Experiments and configurations for these types of payloads were defined to various level of detail in previous NASA and contractor studies. In this study, these data were expanded and integrated into representative payloads to a depth that would permit assessment of ground processing activities.

A detailed description of Level IV Ground Processing Requirements for each of the four representative payloads is presented in the following sections. Three general ground processing concepts used to identify these ground processing requirements are: (1) distributed site (Concept A), (2) payload lead center (concept B), and (3) KSC (concept C). In the case of distributed sites, experiment-to-Spacelab elements will be independently integrated at geographically separated sites with requirements for multiple sites of checkout, servicing, and handling GSE. At a lead center (centralized site), individual experiment-to-Spacelab element integration will be accomplished with sharing of personnel and GSE end items. In the case of KSC concept, shipment of individual experiments will be made to KSC for serial and/or combined installation, integration, and checkout of experiments and Spacelab elements.

A detailed description of the experiments for each of the four payloads is presented in the Appendices under separate cover.



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2.0 ALTERNATE GROUND PROCESSING OPTIONS

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Originally, three Level IV integration ground processing concepts were considered; distributed site, centralized site, and launch sites. The distributed site concept reflected multiple level IV integration activities for a single Spacelab payload at geographically separated locations. The centralized site concept required all experiment equipment and Spacelab mounting/interfacing hardware for a payload at one geographical location. The third concept required all experiment hardware at the launch site, KSC.

All three concepts reflected the same level of assembly and checkout prior to initiation of level III/II integration activities at KSC. Preliminary assessment of the data being developed for each payload for each concept indicated only minor differences, which could be attributed primarily to variations in transportation requirements. In an attempt to provide a broader spectrum of data, Rockwell expanded the number of options within each concept to be considered. The expansion within the three baseline or generic concepts was based upon variations in the experiment/payload integration.

DISTRIBUTED SITE OPTIONS

The principle characteristic of distributed site options is the independent buildup and checkout of Spacelab mounting elements at multiple geographical locations. For example, an experiment system could be installed and checked out in one rack at a site, while other experiment systems were being installed and checked out independently in other racks at other sites. Multiple sets of checkout equipment are also characteristic of this generic concept.

The variations within the generic distributed site concept pertain to the level of payload assembly and checkout activities prior to initiation of level III/II integration activities of the KSC-STC operations. One option (designated A-1) reflects rack/floor and/or pallet train assembly in the STC operations. Also, in the A-1 option, the initial checkout of the integrated payload is accomplished after rack/floor installation into the module, interconnection of the habitable module and pallet(s), and/or installation of the igloo on the lead pallet and interconnection of pallets.

A functional flow diagram for this option is presented in Figure 2-1. A brief description of the activities conducted in each block is presented in Table 2-1. The missing number will be subsequently assigned and the activities identified in subsequent option definitions.

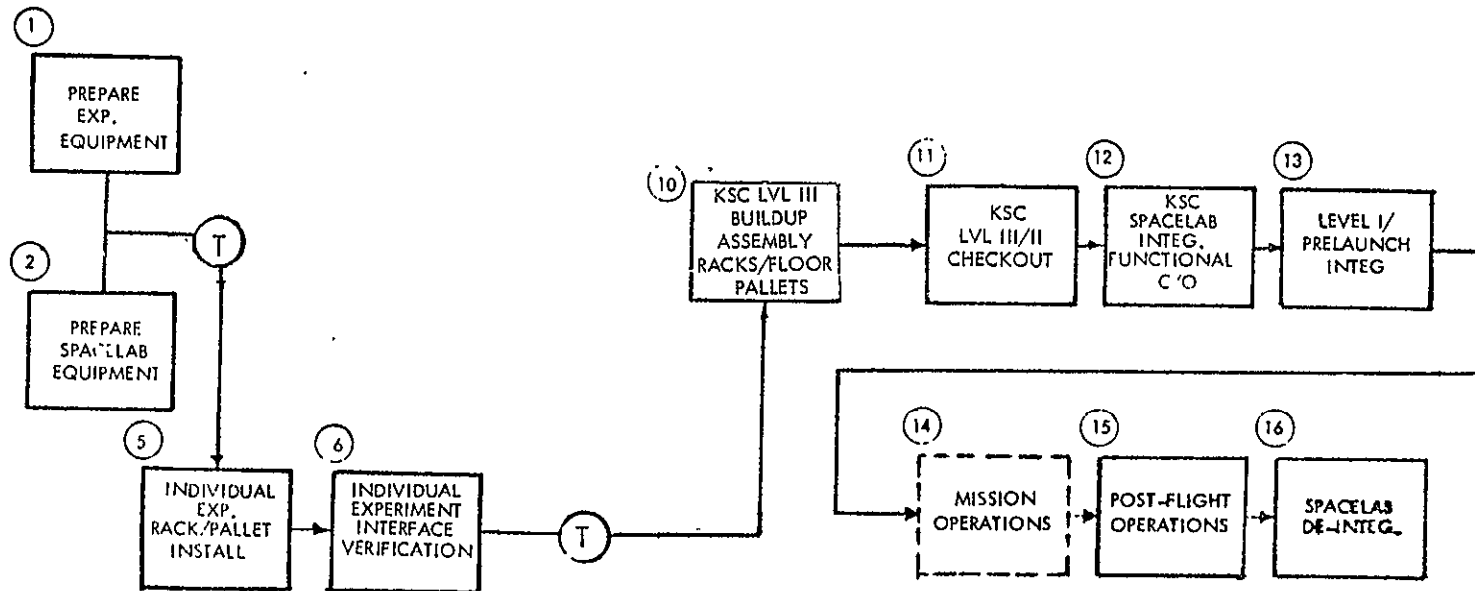


Figure 2-1, Individual Experiment Integration - Level III/II Assembly and Checkout



Table 2-1. Individual Experiment - III/II Assembly Functional Descriptions

Functional Block	Title	Descriptor
1	Prepare Experiment Equipment	Receiving and inspection of experiment equipment at the level IV site. Preparation for move/transfer to the level IV integration area
2	Prepare Spacelab Equipment	Reconfiguration of Spacelab flight hardware to specific configuration and complement of interfacing Spacelab elements required for next payload. Conducted at KSC as part of staging operation. Includes installation of RAU's, I/C's, EPSP/EPDB's, Cold plates, etc.
5	Individual Experiment Rack/Pallet Installation	Installation of intra-rack/pallet cable/fluid lines, mounting of experiment hardware in racks, on floor segments, and on pallet segments. Multiple independent assembly activities conducted as a function of viable subdivision of Spacelab mounting elements and experiment systems for an individual payload. (e.g. single rack, rack set, rack/floor segment, rack/pallet, pallet segment, etc.).
6	Individual Experiment Interface Verification	Functional checkout of interfaces established in block 6. Includes electrical and fluid interconnections. Conducted on individual experiment system basis. Interfaces may or may not be maintained in subsequent transfers and buildups. Includes intra-rack/pallet connections and interfaces between experiment hardware and Spacelab interfacing elements such as RAU's, EPSP/EPDB's, I/C, etc.
10	KSC Assembly Racks/Floors/Pallets	Assembly of subdivided Spacelab mounting element/experiment system (see block 5 description) into payload flight configuration. Includes rack/floor assembly into a short module/long module configuration and mating of pallet segments into pallet trains. Part of KSC-STS-O&C building operations and referred to as level III assembly activity.



Table 2-1, Individual Experiment - Level III/II Assembly Functional Descriptions (Cont'd)

Functional Block	Title	Descriptor
11	KSC Assembly With Electrical/Environmental System and Command/Control System	KSC-STS operations which include installation of rack/floor sites in modules, interconnection of Spacelab and experiment system, installation of end core, pallet and/or pallet train interconnections, and installation of Igloo (as applicable).
12	KSC Spacelab Integrated Functional Checkout	Functional verification of all electrical and fluid interfaces established in blocks 10 and/or 11. Includes: Spacelab subsystem, Spacelab/experiment and intra-experiment connections; data/command transfer interfaces; CDMS/experiment software; and loading/stowage of loose experiment equipment.
13	Level I/Pre-Launch Integration	OPF and Pad operations. Includes: installation of Spacelab/payload into Orbiter bay and dedicated payload control and display panels in Orbiter Aft-Flight-Deck (AFD); functional verification of all electrical and fluid interfaces established during installation; servicing/top-off of payload fluids/consumable; and loading of specimens.
14	Mission Operations	Reference period of seven calendar days to be used in determination of flight hardware involvement times.
15	Post-Flight Operations	Safing of experiment system and off-loading of critical samples, specimens, data prior to O&C building operations.
16	Spacelab De-integration	Removal of rack/floor sets from modules, disassembly of pallet/pallet trains, removal of experiment hardware from Spacelab mounting elements.



The second distributed site option (A-2) reflects combined payload checkout at KSC after independent/individual experiment/mounting element integration at multiple distributed sites but prior to entering STS operations in the O&C building. For purposes of this study, it was assumed that the off-line combined payload checkout activity at KSC would occur in an industrial complex facility. This option is also characterized by the by-passing of the level III assembly activity in the O&C building. For example, independently integrated pallets or pallet trains (pallet-only payload) would be interconnected and checked out at the payload level in the off-line activity, disconnected, and then transported directly to the level II stand in the O&C building.

The third distributed site option (A-3) also includes off-line checkout at the payload level at KSC. However, in this option, level III assembly in the O&C building is required. For example, rack/rack sets from multiple distributed sites would be interconnected and checked out in the off-line activity, disconnected and transported to the O&C building, and then integrated with floor segments in the level III assembly stand.

A functional flow diagram for the A-2 and A-3 options is presented in Figure 2-2. The delta activities for these options are reflected in functional blocks 7, 8 and 9. All other functional blocks are essentially the same as described in Table 2-1. Activities in blocks 7, 8, and 9 are summarized in Table 2-2. The destination from block 9 is dependent upon the configuration of the payload upon arrival at the O&C building. If the payload is in the flight configuration, the flow by-passes block 10 (Option A-2). If level III assembly is required, block 10 is included in the processing flow (Option A-3).

Table 2-2. Delta Activities for Individual Experiment Integration -
Pre III/II Combined Checkout

Functional Block	Title	Descriptor
7	Interim Payload Interconnect	Assembly and/or interconnection of individually integrated Spacelab mounting element/experiment systems into a simulated flight configuration.
8	Combined Payload Checkout	Functional verification of multiple experiment/simulated Spacelab system interfaces. Includes: command/data transfer; power/cooling compatibility; and CDMS/experiment software.
9	Disassembly for Shipment	Dependent upon payload buildup approach and location of combined payload checkout. If payload is in flight configuration at KSC only preparation for transfer to O&C building is required. If transportation width is a

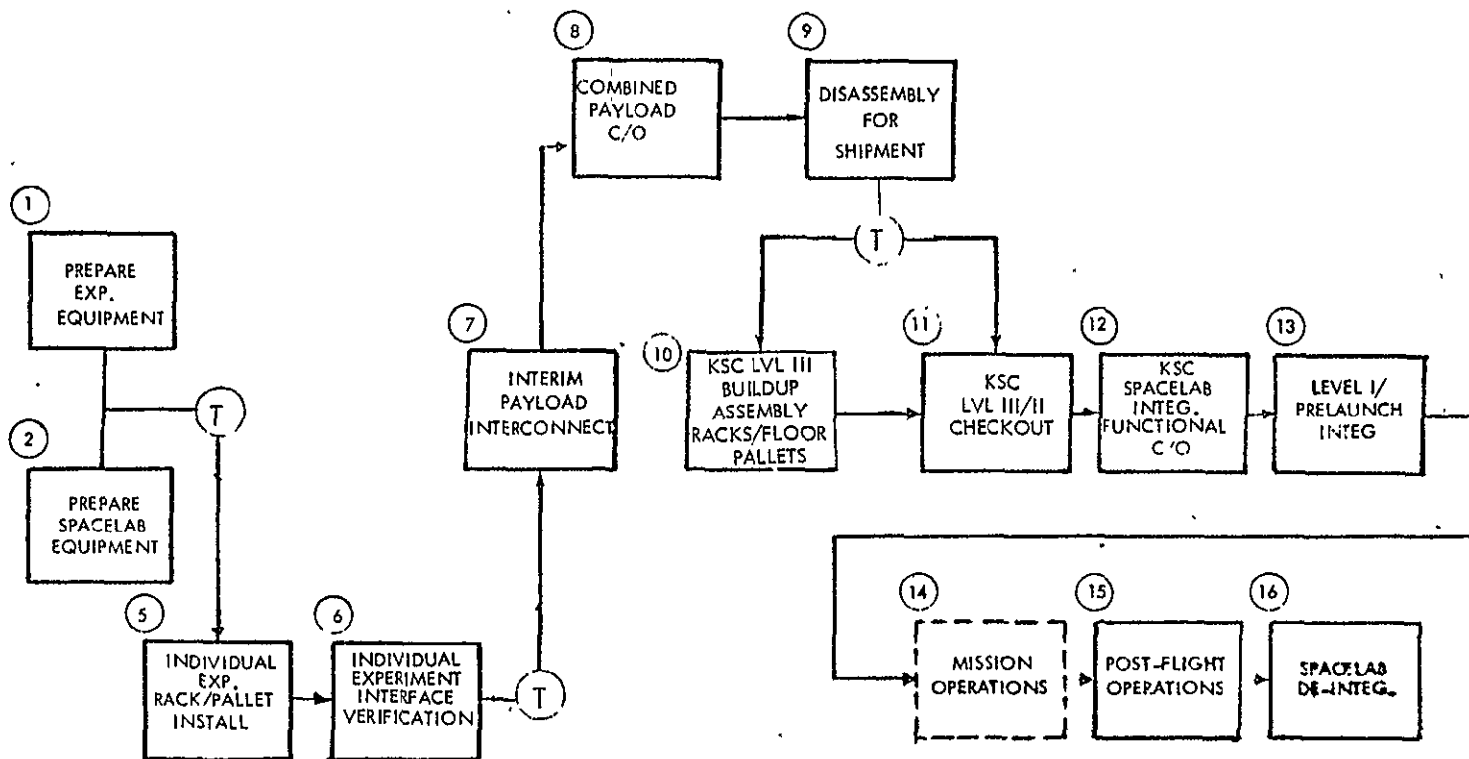


Figure 2-2, Individual Experiment Integration - Pre-Level III/II Combined Checkout



Table 2-2, Delta Activities for Individual Experiment Integration -
Pre III/II Combined Checkout (Cont'd)

Functional Block	Title	Descriptor
9 (Cont.)		constraint (>12 feet) disassembly of long module rack/floor and pallet trains is required. If configuration is only simulated flight configuration individually integrated Spacelab mounting elements must be prepared for shipment.

LEAD CENTER OPTIONS

The generic lead center concept is characterized by the performance of all pre-O&C building integration activities at one geographical location other than KSC. The options within this concept reflect variations in both the level of and approach to assembly and checkout.

The first three lead center options are similar to the distributed site options. Although experiment system/mounting element integrations are conducted on an individual basis, the activities are scheduled to maximize the common usage/sharing of GSE. The first option (B-1) would result in the integration of individual mounting element at a lead center. Subsequently, these elements would be transferred to KSC for assembly into the flight configuration of the payload in the O&C building. Option B-1 is comparable to option A-1.

Options B-2 and B-3 are comparable to options A-2 and A-3 with regards to pre-KSC/STS assembly and checkout status. However, the combined payload checkout activity would be conducted at the lead center rather than in an off-line facility at KSC. Except for the location(s) of this activity the functional blocks in Figure 2-1 and -2 for options A-1, A-2, and A-3 are the same for B-1, B-2, and B-3, respectively.

If level IV integration is conducted at one geographical location installation of the full complement of experiment equipment and/or Spacelab mounting elements prior to checkout is feasible. Option B-4 reflects this possibility. For example, an entire rack/floor set would be available at the level IV site. Intra- and inter-rack and floor cabling would be installed. Experiment equipment would be installed in/on the racks and floor segments. Individual experiment systems would be checked out followed by a combined payload checkout. The totally assembled and integrated payload would then be transported directly to the level II stand in the O&C building.

In order to assess the impact on ground processing of a potential road transportation constraint, a fifth lead center option (B-5) was introduced. Repetitive road transportation through some states may be restricted to a maximum width of twelve feet. This constraint can be met if only single pallet and/or single module rack/floor sets are transported. Thus, for the B-5 option, payload assembly and preparation for shipment activities in the B-4 option were revised to reflect the temporary interconnection of pallet trains and long module rack and floor sets. Also, the level III assembly activity in the O&C building was included in the KSC-STs operations.



The top level functional flow for the B-4 and B-5 options is presented in Figure 2 -3. Only functional blocks 3 (Experiment Installation and Payload Assembly) and 4 (Experiment Interface Verifications) are deltas to the flow presented in Figure 2 -1. Block 3 encompasses the installation of experiment equipment in flight configured rack/floor sets and/or pallet trains. Block 4 includes the sequential and progressive verification of individual experiment systems. The activities within blocks 8, 9, and 10 are similar to those of the previously discussed options, but reflect the integrated payload configuration of options B-4 and B-5.

KSC OPTIONS

In general, the KSC options are a special application of the lead center options. All experiment equipment and Spacelab mounting elements are integrated at one geographical location, KSC. For purposes of this study, it was assumed that all the level IV integration activities at KSC would be conducted in a facility in the industrial complex. The one disparity between the lead center options and the KSC options is that there is no KSC option comparable to B-5. A twelve-foot width constraint during transportation of an integrated payload from the industrial complex to the O&C building at KSC is not applicable.

SUMMARY OF GROUND PROCESSING OPTIONS

A composite of the functional flows for the processing options is presented in Figure 2 -4. A matrix of the twelve options for the three generic concepts and the applicable functional blocks is presented in Figure 2 -5. As stated previously, the first three options for each generic concept encompass the same functional blocks (activities). Options B-4 and C-4 are comparable; Option B-5 is unique to the lead center concept.

The predominant discriminators between options are as follows:

1. Level of pre-KSC/STS integration: Inclusion/exclusion of Combined Payload Checkout - Block 8.
2. Approach to experiment installation: Individual experiment versus payload buildup - blocks 5 and 6 versus blocks 3 and 4.
3. Level III assembly at KSC: Inclusion/exclusion of payload flight configuration buildup at KSC - block 10.

Variations/combinations of A, B, and C options for the ground processing of a payload were briefly examined. Some combinations or hybrids are feasible and quite reasonable. For example, part of a payload might be integrated at a distributed site (A type option) and then combined with the remainder of a payload at a lead center (B type option) prior to transfer to KSC. The assessment of these types of hybrid options would not significantly expand the spectrum of data of the basic twelve options because the costs of the payload segments processed at two different sites would bear the same relationship as the

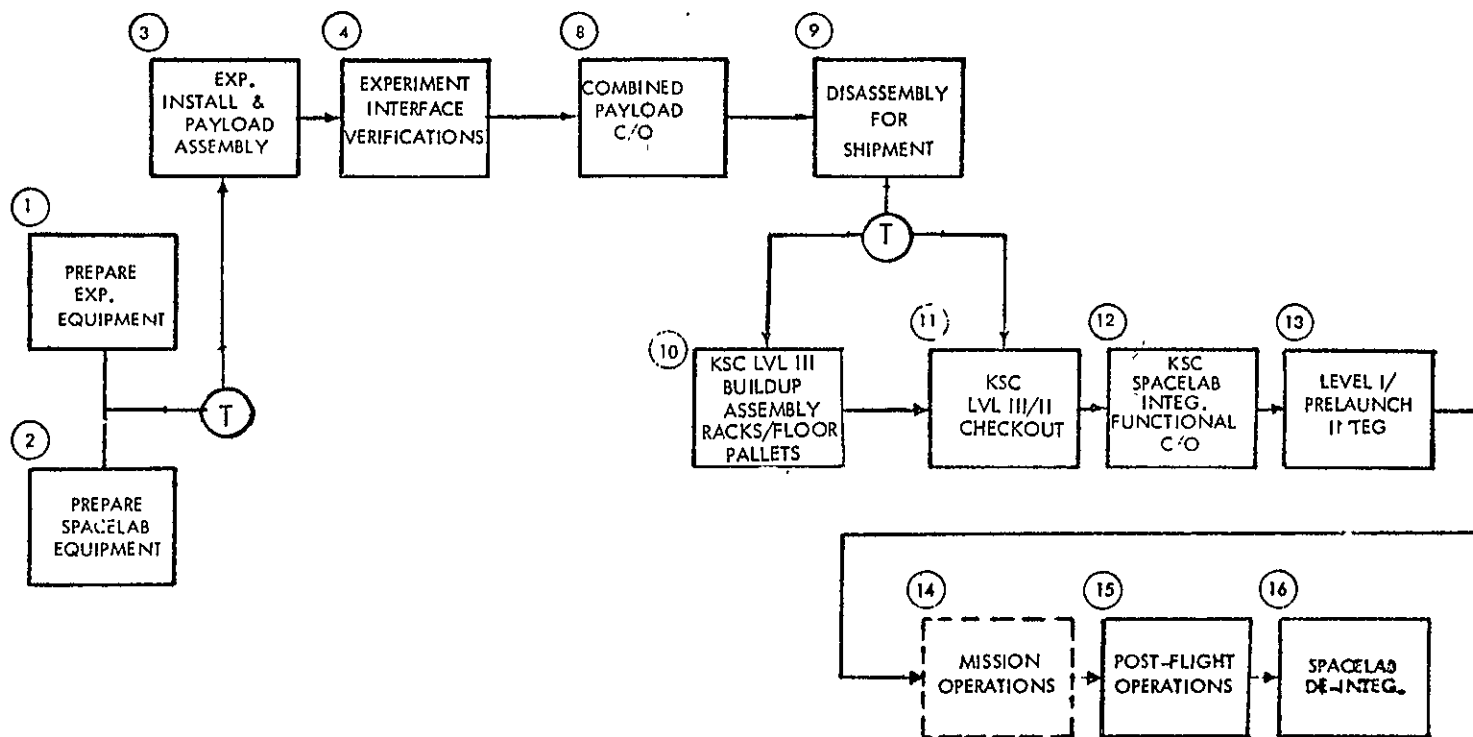


Figure 2-3, Payload Assembly and Checkout - Disassembly for Transportation

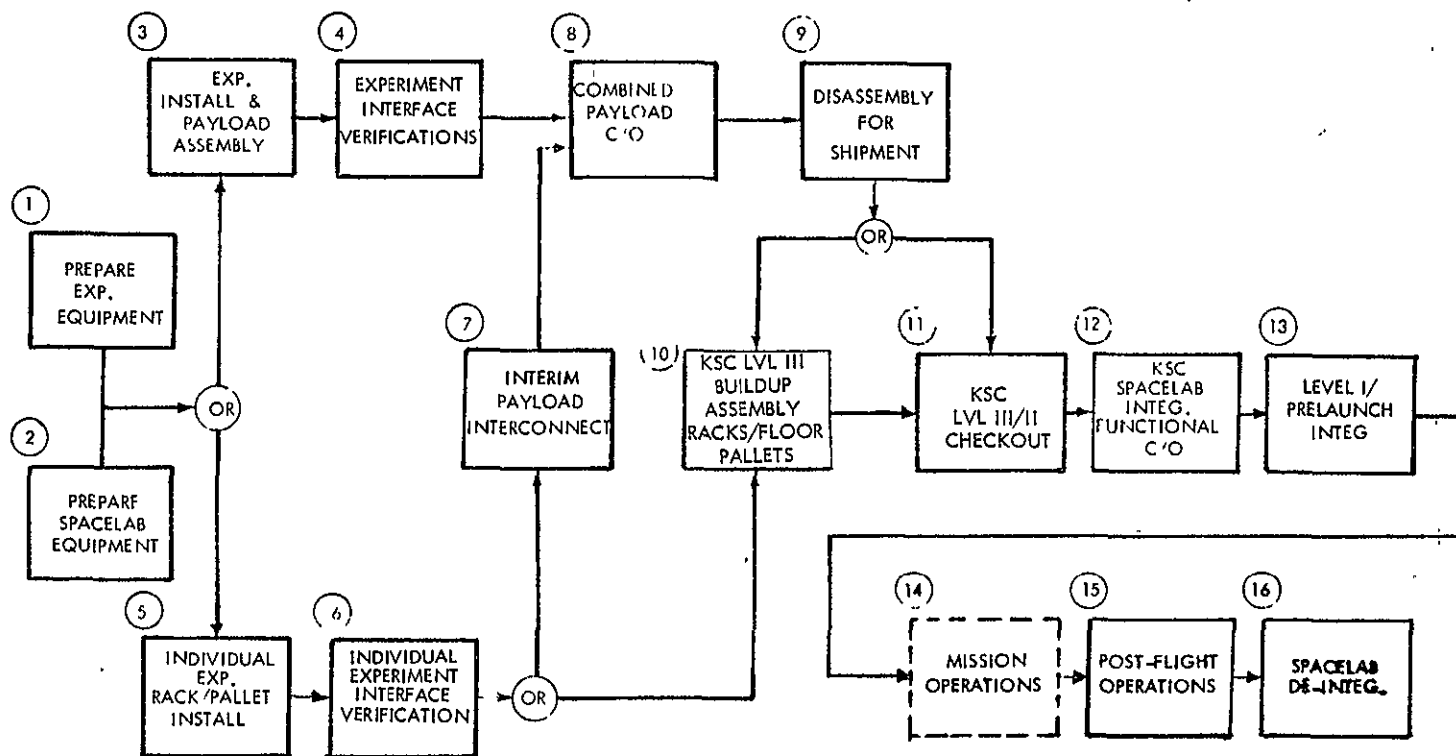


Figure 2-4, Ground Processing Options - Top Level Functional Flow

OP- TION	DESCRIPTOR	APPLICABLE ACTIVITY BLOCK															
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
A-1	IND EXP C/O	PI	LS			D	D				LS	LS	LS	LS	LS	LS	LS
A-2	IND EXP C/O-INT EXP C/O-ONLA	PI	LS			D	D	LS	LS	LS		LS	LS	LS	LS	LS	LS
A-3	IND EXP C/O-INT EXP C/O-OFLA	PI	LS			D	D	LS	LS	LS	LS	LS	LS	LS	LS	LS	LS
B-1	DEP EXP C/O	PI	LS			C	C				LS	LS	LS	LS	LS	LS	LS
B-2	DEP EXP C/O-INT EXP C/O-ONLA	PI	LS			C	C	C	C	C		LS	LS	LS	LS	LS	LS
B-3	DEP EXP C/O-INT EXP C/O-OFLA	PI	LS			C	C	C	C	C	LS	LS	LS	LS	LS	LS	LS
B-4	P/L ASSEMBLY-C/O-ONLA	PI	LS	C	C				C	C		LS	LS	LS	LS	LS	LS
B-5	P/L ASSEMBLY-C/O-OFLA	PI	LS	C	C				C	C	LS	LS	LS	LS	LS	LS	LS
C-1	DEP EXP C/O	PI	LS			LS	LS				LS	LS	LS	LS	LS	LS	LS
C-2	DEP EXP C/O-INT EXP C/O-ONLA	PI	LS			LS	LS	LS	LS	LS		LS	LS	LS	LS	LS	LS
C-3	DEP EXP C/O-INT EXP C/O-OFLA	PI	LS			LS	LS	LS	LS	LS	LS	LS	LS	LS	LS	LS	LS
C-4	P/L ASSEMBLY-C/O-ONLA	PI	LS	LS	LS				LS	LS		LS	LS	LS	LS	LS	LS

LEGEND:

A-X DISTRIBUTED SITE OPTIONS
 B-X CENTRALIZED SITE OPTIONS
 C-X LAUNCH SITE OPTIONS

IND INDEPENDENT
 EXP EXPERIMENT
 C/O CHECKOUT
 OFLA OFF-LINE ASSEMBLY
 D DISTRIBUTED SITE
 LS LAUNCH SITE

ONLA ON-LINE ASSEMBLY
 DEP DEPENDENT
 INT INTEGRATED
 P/L PAYLOAD
 PI PRINCIPAL INVESTIGATOR
 C CENTRALIZED SITE

Figure 2-5, Matrix of Processing Options

total cost of the payload processed by the same processing site. These hybrid options could therefore be constructed from elements that are in existing data. Also, the twelve options could be extrapolated to various hybrids if other factors indicated the desirability of a hybrid ground processing approach for an individual payload.

QUALITATIVE ASSESSMENT OF OPTIONS

In subsequent sections of this report, specific ground processing resource requirements will be developed for each of the applicable options for each representative payload. Included in these resources will be manpower, travel, GSE, flight hardware, and transportation/shipment costs. In addition to these factors, a relative comparison of the staffing, facility, GSE, operations, and management aspects of the alternate Level IV integration approaches was made (Table 2-3). Although aerospace firms and NASA centers are potential distributed site candidates, the evaluations for this approach are more indicative of industrial/commercial firms and university/science centers. Lead center evaluations assume either a major NASA aerospace center or a major aerospace contractor. Availability of appropriate facilities at KSC is assumed in the KSC evaluations.

These subjective evaluations indicate the following trends:

1. Distributed site options are the most advantageous for experimenters but probably the most complex for the Spacelab program.
2. Maximum use/minimum logistics of Spacelab equipment can be achieved with the KSC options, but experimenter logistics are maximum.
3. Lead center options provide a reasonable focal point/compromise between experiment and Spacelab program considerations.
4. Pre-KSC-STS operations will reduce the probability of incompatibilities between experiments and Spacelab and thus the potential for schedule impact on STS operations. However, the potential for damage/misuse of Spacelab equipment increases, and nominal flight and GSE hardware involvement times per mission increase.

Table 2-3. Qualitative Assessment of Ground Processing Concepts

Category	Considerations	Distributed Site	Lead Center	KSC
Personnel	Availability	Extension of development personnel already dedicated to experiment.	Limited extension of experiment development personnel. Potential for cadre of aerospace technician personnel - dependent upon flight rate.	Minimum experiment oriented personnel. Maximum potential for cadre of aerospace personnel.
	Skill Mix	Excellent scientific/experiment but minimal aerospace/Spacelab skills. Broad spectrum required among relatively small groups.	Nominal scientific, excellent aerospace, potentially excellent Spacelab skills-dependent upon flight rate.	Minimal scientific, excellent aerospace and Spacelab.
	Relocation	Minimum - distributed sites are the experimenter's home base.	Nominal - assumes some experiments are sponsored by lead center.	Maximum - probably all experiment oriented personnel will be on TDY.
	Duplication	Minimum scientific personnel duplication but maximum aerospace and Spacelab oriented personnel requirements because of multiple sites.	Minor scientific. Potentially minimum aerospace and Spacelab oriented personnel duplication - dependent upon flight rate.	Assumed scientific personnel TDY. Minimal aerospace and potentially negligible Spacelab personnel if S/L integration and/or staging personnel can also support level IV integration activities.

Table 2-3. Qualitative Assessment of Ground Processing Concepts (Cont'd)

Category	Considerations	Distributed Site	Lead Center	KSC
Facilities	Availability	Assumed	Compatibility is an assumed prerequisite to be designated a lead center.	Reassignment of industrial complex facility required
	Modifications	Access width/height and crane/cleanliness requirements may be constraints.		Moderate modifications required
	Environment	Most familiar with experiment constraints which probably supercede Spacelab constraints. Could be extension of experiment development environment.		Established expertise in processing of scientific equipment.
	Transportation Access	May limit viable candidate sites because over-the-road transportation and/or airport proximity.		No constraints, air, barge, or road.
	Safety	Potential hazards in handling size/weight of Spacelab elements.		No constraints; standard operating procedures.

Table 2-3. Qualitative Assessment of Ground Processing Concepts (Cont'd)

Category	Considerations	Distributed Site	Lead Center	KSC
GSE	Availability	Maximum experiment related and special purpose. Requires loan/logistics of Spacelab related GSE.	Nominal experiment and special purpose GSE. Potential for adequate on-site Spacelab GSE-dependent upon flight rate and assignment of dedicated GSE.	Limited experiment GSE. Maximum spectrum of Spacelab GSE. KSC assumed to be depot for Spacelab oriented GSE.
	Inventory	Requires duplication of numerous items of level IV (Spacelab) GSE.	One set of level IV GSE. Could be dedicated - dependent upon flight rate.	Minimum inventory because of proximity of GSE depot and potential for sharing numerous items.
	Logistics	Minimum experiment but maximum Spacelab.	Nominal experiment. Could be minor/negligible Spacelab GSE logistics if flight rate supports dedication.	Maximum for experiment related logistics but minimum/simplest for Spacelab GSE.
	Maintenance	Excellent for experiment GSE but relatively poor for Spacelab GSE.	Assumed relatively broad spectrum of scientific instrumentation capability plus partial payload sponsorship. Spacelab GSE expertise dependent upon flight rate/dedication.	Limited experiment GSE expertise but excellent Spacelab GSE maintenance capability - KSC is the assumed GSE depot.

Table 2-3. Qualitative Assessment of Ground Processing Concepts (Cont'd)

Category	Considerations	Distributed Site	Lead Center	KSC
Operations	Level of Payload Assembly and Checkout	A-1 Minimum; individual experiment systems only A-2/3 Simulated payload combined checkout will be used. —	B-1 same. B-2/3 same. B-4/5 Integrated payload configuration.	C-1 same. C-2/3 same. C-4 same.
	STS Operations and Schedule Risk	A-1 Maximum; only individual experiment systems verified in non-flight (payload configuration at multiple sites) A-2/3 Less than above option but still significant risk because of simulated payload configuration.	B-1 Major; although comparable assembly and checkout as A-1, centralized activity would facilitate inter-experiment coordination. B-2/3 Same as distributed site. B-4/5 Minor; transportation affects are primary concern.	C-1 Same as lead center plus additional opportunity for closer coordination with Spacelab equipment staging activities. C-2/3 Same as distributed site. C-4 Minimum; transportation should have negligible affect.
	Transportation and Handling	Maximum for Spacelab equipment but minimum for experiment equipment.	Nominal for both Spacelab and experiment equipment.	Nominal for Spacelab equipment (shorter duration) but maximum for experiment equipment.

Table 2-3. Qualitative Assessment of Ground Processing Concepts (Cont'd)

Category	Considerations	Distributed Site	Lead Center	KSC
Operations (Cont'd)	Accommodation of Experiment Contingencies and Risks	Excellent because located at or close to experiment facilities	Nominal, assuming cadre of experiment oriented personnel	Minimum- Limited experiment oriented personnel
	Spacelab Equipment Maintenance	Minimum - Limited Spacelab expertise	Limited - dependent upon traffic rate and establishment of Spacelab oriented cadre	Excellent -because KSC assumed to be depot for Spacelab elements Same as lead center
	Assembly and Checkout Standards	Minimum standardization; however, readily adaptable or tailored to individual experiment requirements.	Standardization with adequate flexibility for unique requirements.	
	Probability of Flight Hardware Damage/Misuse	Minimum for experiment equipment; maximum for Spacelab equipment.	Nominal, assuming cadre of Spacelab oriented personnel is developed.	Nominal, same as lead center
Management	Planning and Scheduling	Simplest, decentralized, and decoupled.	Requires interrelationships and interdependencies to achieve desired efficiencies.	Similar to lead center; simpler transportation but more complex GSE planning to achieve desired sharing/utilization.
	Configuration Management	Probably simple and informal for experiments but complex/involved for Spacelab equipment.	More rigorous for experiments, easier to coordinate for Spacelab.	Same rigor for experiments and simplest for Spacelab.

Table 2-3. Qualitative Assessment of Ground Processing Concepts (Cont'd)

Category	Considerations	Distributed Site	Lead Center	KSC
Management (Cont'd)	Documentation	Simple/informal for experiments. Multiple and rigorous for Spacelab.	More rigorous for experiments, simpler for Space-lab because of fewer items involved and development of expertise - dependent upon flight rate.	Same level for experiments. Transportation and GSE documentation differences between lead center and KSC concepts tend to offset each other.
	Gov't. Furn. Equip. (GFE) such as racks/pallets furnished for integration	Complex and inter-dependent.	Readily controlled at the payload level.	Readily controlled at the program level.
	Logistics	Maximum effort required for Spacelab; minimum required for experiments.	Nominal if lead center is partial payload sponsor.	Maximum effort required for experiments and nominal for Spacelab equipment.
	Administration	Decentralized and decoupled for experiments but most complex for Spacelab.	Nominal for both experiments and Spacelab.	Same as lead center.

3.0 PAYLOAD INSTALLATION & TEST REQUIREMENTS

3.0 PAYLOAD INSTALLATION AND TEST REQUIREMENTS

INTRODUCTION

In this section, a baseline set of ground processing requirements is developed for each representative payload. These requirements reflect basic guidelines applicable to Spacelab/payload integration, processing option variations because of payload configuration differences, and standardized task estimating criteria. In the estimating criteria, the specific integration tasks were delineated in waterfalls for each option and each task was analyzed to establish the personnel, transportation, GSE, and Spacelab flight hardware utilization.

Baseline Concept Development Guidelines

A baseline approach to ground processing activities for each payload was established with a set of guidelines/assumptions pertaining to pre-Level IV integration activities as well as Level IV activities. Subsequent system level trades were conducted to determine the cost implications of some of these guidelines. These trades are shown in Section 2 Volume III. The principle guidelines used were:

- 1) All Spacelab interfacing hardware and experiment equipment will be in operable condition and ready for installation/integration and the initiation of level IV activities.
- 2) The Spacelab interfacing element will be available at the level IV site. That is, regardless of what the element is (rack, pallet, IPS, SIPS, RAU, EPDB, EPSP, I/C, coldplate, inverter, etc.), it was assumed that it would be available at the level IV site.
- 3) Interfacing elements such as RAU's, EPDB's, EPSP's, I/C's, and coldplates will be installed in/on racks and pallets during staging operations at KSC.
- 4) Interconnections between coldplates on pallets and transition cables/coolant lines on forward pallets will be installed during staging operations at KSC.
- 5) Integration of instruments/sensors with SIPS canisters is accomplished prior to level IV activities.
- 6) Integration of experiment sub-assemblies that will be installed as a single end item in/on Spacelab mounting elements or payload unique support structure will be accomplished prior to level IV activities.
- 7) Where practical, currently defined Spacelab and payload GSE will be used/adapted for level IV integration activities.
- 8) In general, checkout activities will consist of verification of installation and interconnection operations. Specification, performance, end-to-end,



or calibration tests will be conducted if the installation/interconnection operation affects these parameters.

- 9) Repetition of a test is required if an interface is interrupted for reasons of transportation or subsequent assembly operations.
- 10) None of the Spacelab equipment located in the Igloo or subsystem racks of the module are available during level IV activities.

Applicable Payload Options

Based upon the basic processing guidelines and the configurations of the representative payloads, the applicability of the ground processing options (defined in Section 2) to the four payloads was determined. The applicability is summarized in Table 3-1. Note that the pallet only payloads, Combined Astronomy and Space Processing, do not require level III assembly at KSC. The other two payloads, Life Sciences and ATL, require level III assembly at KSC except in those options that include integrated payload assembly and transportation (B-4 and C-4).

Table 3-1. Options Applicable to Each Payload

PAYLOAD	APPLICABLE OPTIONS	RATIONALE
COMBINED ASTRONOMY	A-2 B-2, B-4 C-2, C-4	LEVEL III ASSEMBLY AT KSC (BLOCK 10) IS NOT REQUIRED FOR THIS PAYLOAD.
SPACE PROCESSING	A-2, B-2, B-4 C-2, C-4	LEVEL III ASSEMBLY AT KSC (BLOCK 10) IS NOT REQUIRED FOR THIS PAYLOAD.
ADVANCED TECHNOLOGY LABORATORY	A-1, A-3 B-1, B-3, B-5 C-1, C-3	LEVEL III ASSEMBLY AT KSC IS REQUIRED IF INDIVIDUAL EXPERIMENT BUILDUP IS USED (BLOCKS 5 & 6) OR PALLET SEGMENTS ARE DISCONNECTED FOR SHIP. (BLOCK 9)
	B-4, C-4	LEVEL III ASSEMBLY IS NOT REQUIRED IF COMBINED EXPERIMENT BUILDUP IS USED, AND PALLET TRAIN IS SHIPPED.
LIFE SCIENCES	A-1, A-3 B-1, B-3, B-5 C-1, C-3	LEVEL III ASSEMBLY AT KSC IS REQUIRED IF INDIVIDUAL EXPERIMENT BUILDUP IS USED (BLOCKS 5 & 6) OR RACK/FLOORS FOR BOTH MODULES ARE DISCONNECTED FOR SHIPMENT. (BLOCK 9)
	B-4, C-4	LEVEL III ASSEMBLY IS NOT REQUIRED IF COMBINED EXPERIMENT BUILDUP IS USED AND FLOOR SETS ARE DURING BUILDUP.



Standardized Time Estimates

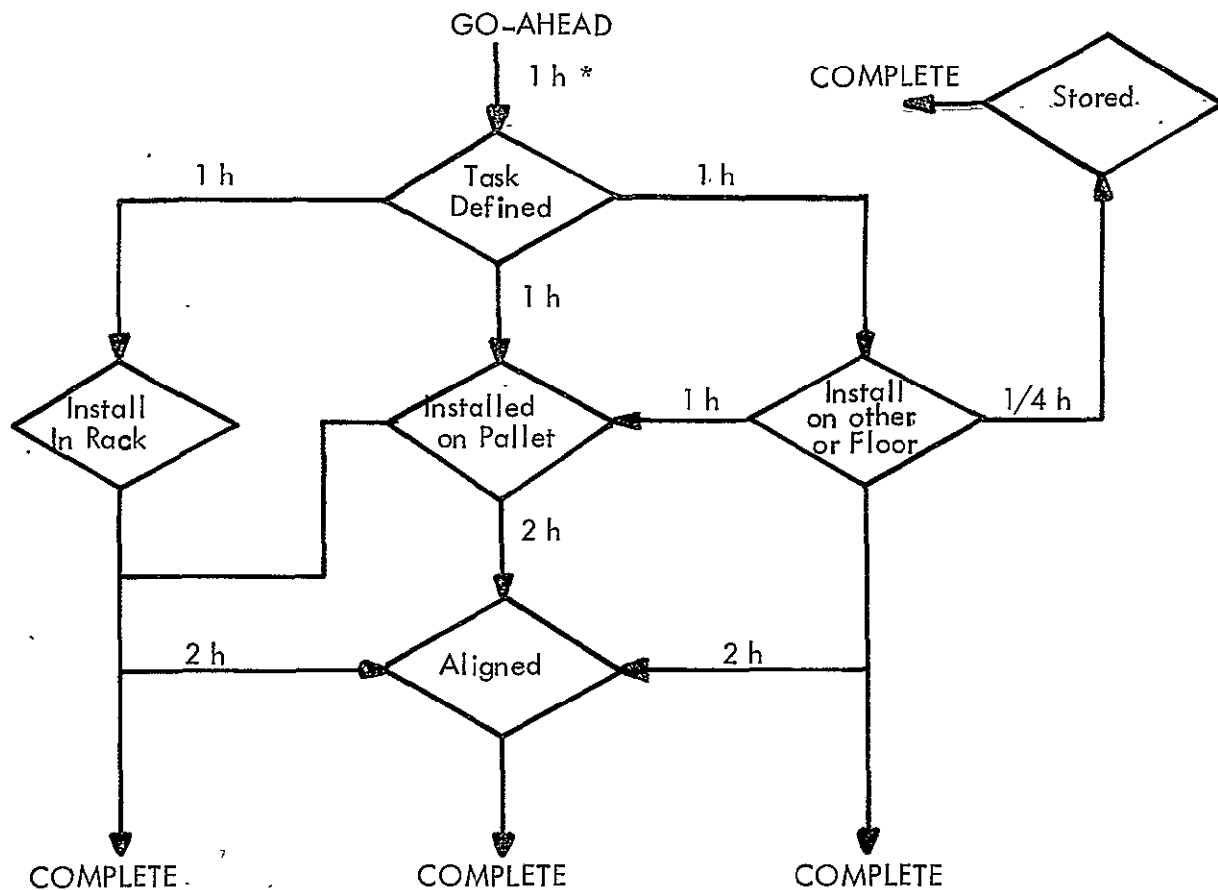
In order to provide for consistency of task estimates between options and payloads, standardized time estimating procedures were developed.

Factors for estimating the time required to perform an installation operation were established using prior Rockwell experience on Shuttle and other space-related programs. Time and motion study reports were also examined. The data compiled was related to a model shop type environment which best simulates the Level IV assembly effort. A separate estimating criteria was established for Structural/Mechanical end items, cables/harnesses, rigid fluid lines and verification. The resulting time estimates were used as averages and were modified by engineering judgement to best reflect the complexity of the installation and/or end items.

The estimating methodology for structural/mechanical installation is illustrated in Figure 3-1. For example, if six individual experiment assemblies that can be readily handled by two people are to be mounted in a Spacelab rack the total time required would be seven hours; one hour for task preparation and one hour for each unit. However, if one assembly occupies the entire rack, a mechanical assist is required and the "per unit" installation time increases to three hours. If alignment after installation is required, an additional two hours was allocated. Mounting of experiment assemblies on payload unique support structure was also included, and is indicated as a task comparable to installation of experiment equipment on a floor segment of the module.

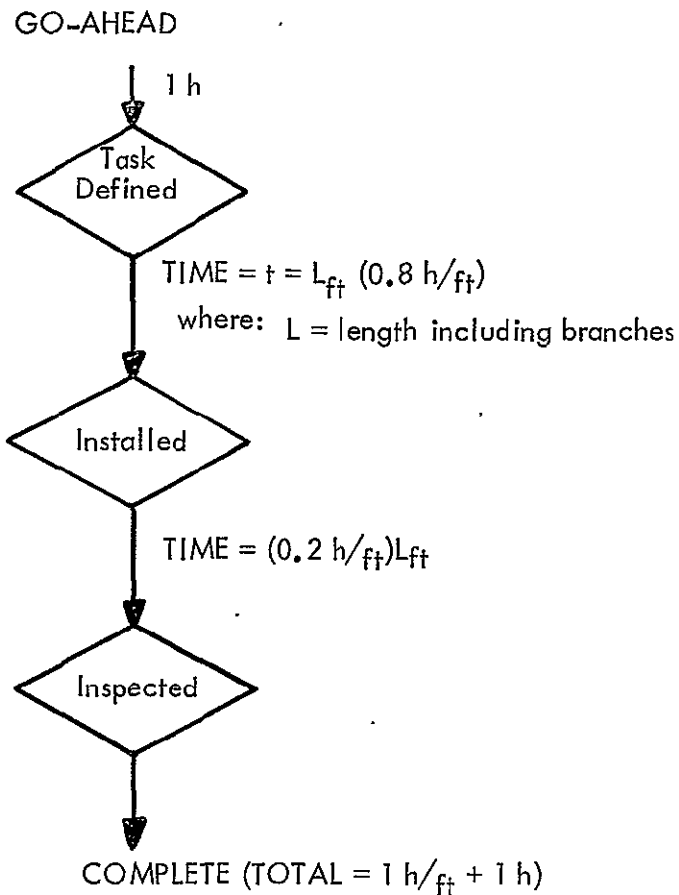
Time estimates are for nominal installations. If a major installation such as mounting of the SIRTf on a two pallet train is involved, then an individual evaluation of the task was conducted.

Task estimates for cable harness installations are shown in Figure 3-2. Activities included in these estimates are final dressing of cable/harnesses, installation of harness restraints (P-clamps), and connection to equipment.



1. Use for average end items only, additional complexity requires additional time.
2. Inspection time included.
3. Alignment requires special instrument support.
4. Add 2 hours if hoist used for complexity
- * 5. One hour for "task defined" occurs only once per rack, for pallets, floors, and others, occurs every end item.

Figure 3-1. Structural/Mechanical Task Estimates



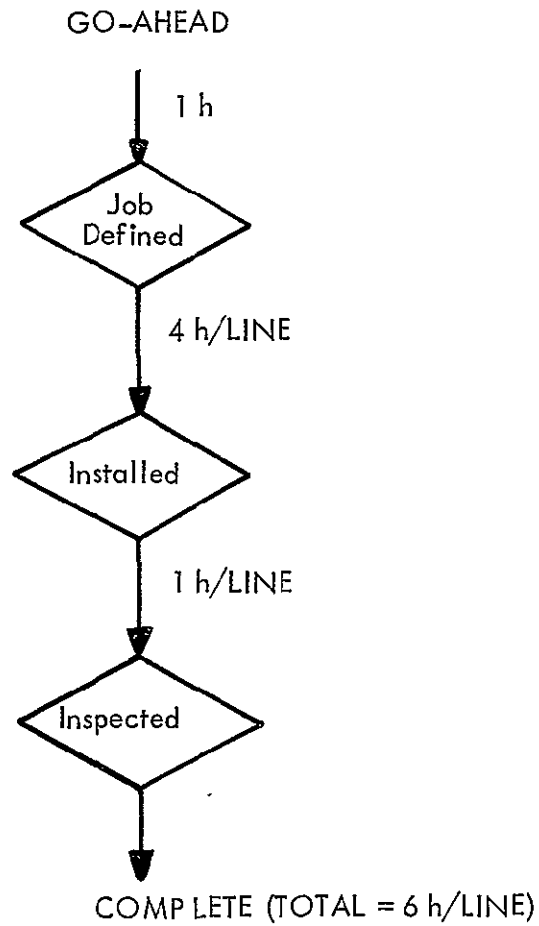
1. For central Level IV integrator harness installation in racks
 $L_{ft} = 6 \text{ ft} + \text{no. of branches}$
2. Individual experiment installation and test sequences (waterfalls) will include estimates of installing cables/harnesses for each experiment. Where reasonable incorporate cables into harnesses for the individual experiment.
3. Round-off times to nearest hour.

Figure 3-2. Cable/Harness Task Estimates



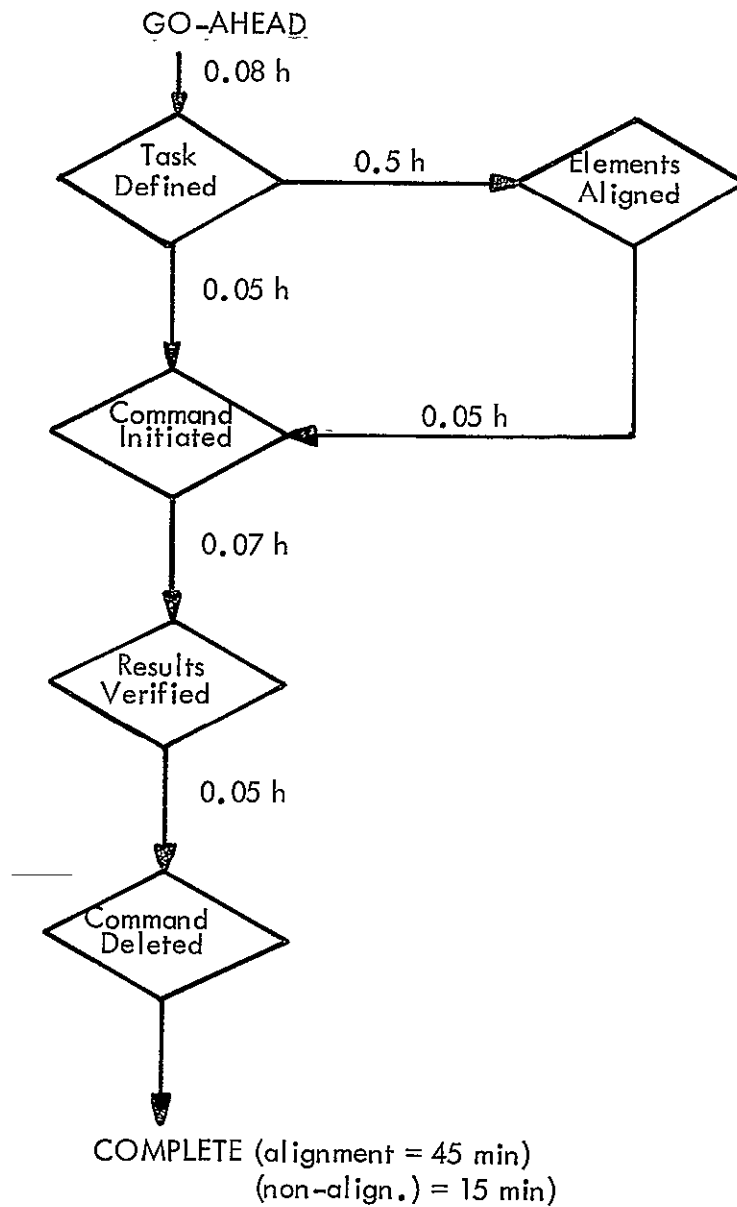
Rigid/fluid line estimates are shown in Figure 3-3. Pre-forming of rigid lines is assumed. Installation of line restraints and interconnection is included in the estimates.

The estimation methodology for interface verification is shown in Figure 3-4. Set-up time is not included because a flat time of one hour per GSE cable or flex line hookup is added to the task estimate. The estimates reflect the issuance of a command (switch closure, keyboard entry, etc.) and verification of the required response. If verification of response is accomplished in real time by meter, indicator light, or CRT readout, the estimate applies. If post-test data stripout or analysis is required, a separate assessment of the task was conducted.



1. Estimate flex line installation time using method used for electrical cable/harness time estimates.

Figure 3-3. Rigid/Fluid Line Task Estimates



1. Does not include check-out equipment hookup.

Figure 3-4. Verification Task Estimates



SPACE PROCESSING PAYLOAD INSTALLATION & TEST REQUIREMENTS

The Space Processing payload is a single pallet-only Spacelab configuration (Figure 3-5). The experiments of this payload consist of alternate materials processing operations on a broad spectrum of samples. The materials processing operations are conducted in four basic melt facilities: electromagnetic levitation, acoustic levitation, multi-purpose furnace, and a float zone refining/crystal growth furnace. The materials samples of each experiment are installed in the appropriate facilities during assembly of the facilities. Sample installation is considered to be a pre-level IV activity. Thus, the installation and integration of the facility equipments with the Spacelab mounting element (pallet) are the activities addressed in the level IV ground processing requirements definition.

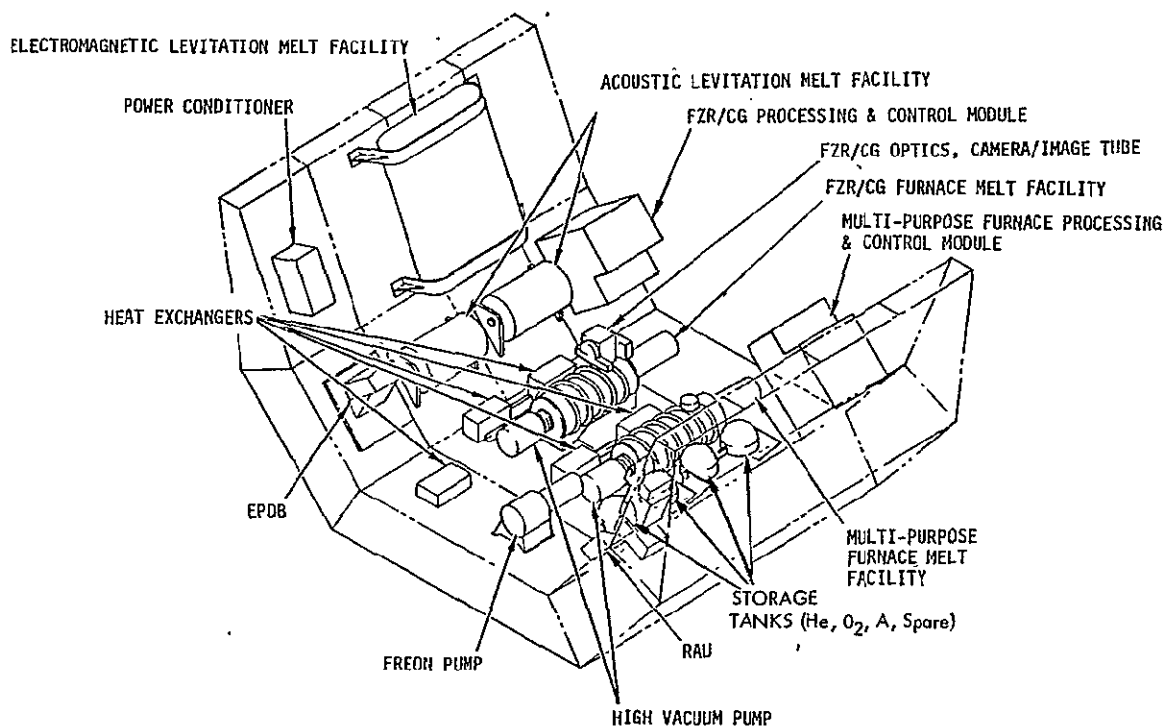


Figure 3-5. General Arrangement - Space Processing Payload

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Applicable Ground Processing Options

As the Space Processing payload is a single pallet configuration, the variation in the installation and checkout tasks between ground processing options is minor. Primary variations in costs may result from transportation and temporary relocation of personnel.

The level IV integration scenario for the Space Processing payload is essentially the same for distributed site, lead center, and KSC options. During staging operations at KSC, interfacing elements (coldplates, RAU's, EPDB, inverter, freon pump, etc.) are installed on the pallet. The pallet is transported to the level IV site for installation of the equipment items of the four facilities. Interconnecting electrical harnesses and coolant/fluid lines are installed. Individual facility checkouts are conducted, followed by a combined payload checkout. Payload unique Orbiter AFD controls and displays and a simulated CDMS are used in the checkout operations. The integrated Space Processing payload is then shipped to KSC for installation/integration of the Igloo in the main stand in the O&C building.

Transportation of the pallet to/from a distributed site or a lead center are the same. Standard Spacelab program handling/transport GSE is used. A nominal time allocation of five days is applicable for the trip to and from these sites. In the KSC options, level IV integration is assumed to be performed in the Industrial Complex and only one day for transportation to and from the complex is allocated.

Personnel requirements to do the "hands-on" tasks are the same in all options. However, the level of host center support will vary depending upon whether the integration occurs at a distributed site (PI's facility), lead center (payload sponsor), or KSC. Also, the TDY will vary in a similar manner. If the distributed site approach is used, TDY will be minimum. If the KSC approach is used, TDY will be maximum. The Lead Center will be somewhere in between.

Installation Requirements

The equipment to be installed and verified in the Space Processing Payload can be categorized into three types: Experiment Equipment (that which is directly used in performing the experiment and is built, tested and supplied by the PI), Common Support Equipment (items which are necessary to provide physical, electrical, data, fluid or other support to the experiment equipment and to interconnect it with the Spacelab and Orbiter), and Spacelab-unique equipment (Modular payload support equipment provided under the Spacelab program by NASA).

Experiment Equipment

In all options, a degree of preassembly of the facilities is performed by PI personnel prior to level IV activities. For example, the material samples are installed in the electro-magnetic and acoustic levitation facilities, the facilities are sealed, and charged with gas prior to level IV activities. In the case of the two melt furnaces, the samples are installed in an insertion, retrieval, and storage device which is assembled with an inner chamber,



common chamber and turbo-pump as a complete assembly prior to level IV activities. Thus, the list of experiment equipment to be installed during level IV activities reflects the pre-assembly of the facilities.

Table 3-2 lists those items of Experiment Equipment associated with each facility and experiment which are to be installed during Level IV integration. One item, EI-1 of each facility, is a control and display panel which is not actually integrated until Level I, when it is installed in the Orbiter AFD (See Figure 3-6). However, it is required in level IV to verify the formal fit of the panel and to verify the functional interfaces established in level IV integration.

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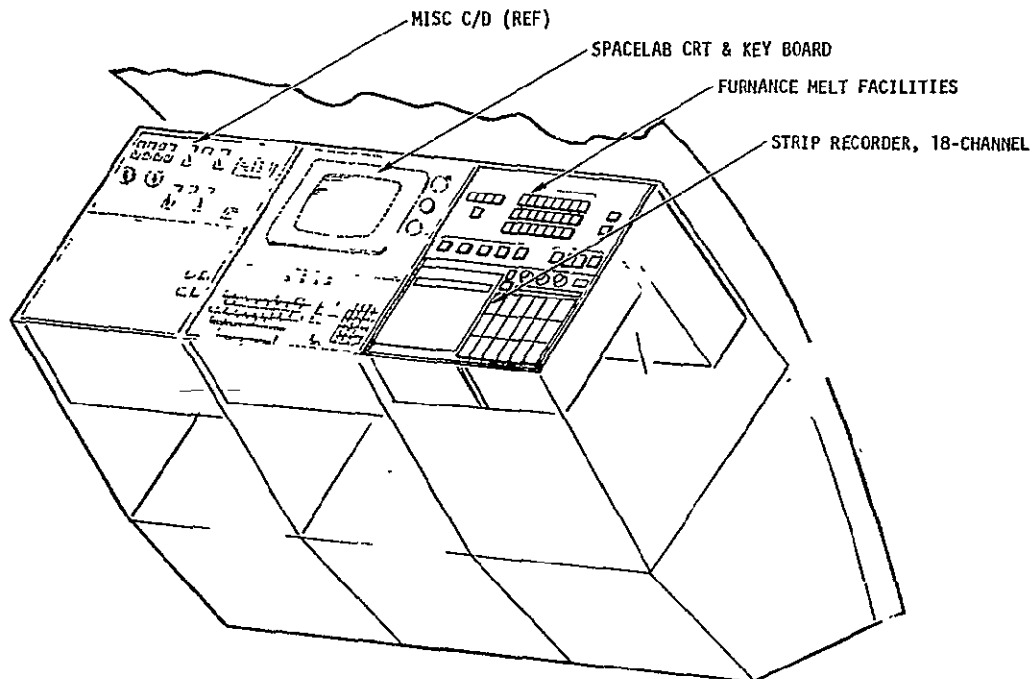


Figure 3-6. Orbiter Aft Flight Deck Arrangement-
Space Processing Payload

Table 3-2. Space Processing Payload End Items

FACILITY #1 Electromagnetic Levitation Melt Facility	FACILITY #2 Acoustic Levitation Melt Facility	FACILITY #3 Multipurpose Furnace	FACILITY #4 Float Zone Refiner/Crystal Growth Furnace
(Exp. S-9A, S-9B, S-21)	(Exp. CG-5, CG-7)	(Exp. S-4, S-7, S-14)	(Exp. S-6, S-16, S-25)
EI-1 - Control/Display Panel (shared by all fac.)	EI-1 - Control/Display Panel (shared by all fac.)	EI-1 - Control/Display Panel (shared by all fac.)	EI-1 - Control/Display Panel (shared by all fac.)
EI-2 - Processing Chamber (3 chambers)	EI-2 - C.G.-5 Processing Chamber (1)	EI-2 - Power Conditioner (shared w/Fac. 4)	EI-2 - Power Conditioner (shared w/Fac. 3)
	EI-3 - C.G.-7 Processing Chamber (1)	EI-3 - Furnace System (incl. Turbo-pump, core, IR&S, Common chamber)	EI-3 - Furnace System (incl. same as Fac. 3 plus optical system)
		EI-4A Gas/Liquid Heat Exchanger	EI-4A Gas/Liquid Heat Exchanger
		EI-4B Gas Tank Assembly	EI-4B Gas Tank Assembly
		EI-4C Freon Pump (shared w/Fac. 4)	EI-4C Freon Pump (shared w/Fac. 3)
		EI-5 Processing and Con- trol Module	EI-5 Processing and Con- trol Module

3-12

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Common Support Equipment

This equipment, which is generally payload-peculiar, consists of cabling, tubing, bracketry, cable trays and similar items which are designed to provide the necessary support to the experiment equipment above and beyond that provided by the Spacelab equipment. As such, it consists specifically of the following items for the Space Processing Payload.

- (a) Power and signal cable assemblies as listed in Volume I.
- (b) Freon, coolanol and high pressure gas tubing assemblies as listed in Volume I.
- (c) Furnace supports for mating the Multipurpose and Float Zone re-finer/Crystal Growth Furnaces to the pallet floor.
- (d) Cable and tubing trays and supports to mount items (a) and (b) to the pallet structure.

Spacelab-Unique Equipment

The Spacelab equipment, previously defined, consists of the following items:

- (a) One pallet
- (b) One 400 Hz AC inverter
- (c) One Remote Access Unit (RAU)
- (d) One Freon Pump and Accumulator package
- (e) One Experiment Power Distribution Box (EPDB)
- (f) One Experiment Heat Exchanger
- (g) Four coldplates

In the flight configuration, an Igloo is also required, complete with all Spacelab data and power subsystems, but this is not needed for Level IV integration and is assumed not to be supplied, hence is not included in the above list. During Level IV integration, a simulator will be used which provides the CDMS and power requirements.



Special Handling, Checkout, Servicing and Auxiliary Ground Equipment

In addition to the flight equipment installed on the pallet in the process of Level IV integration, a complement of ground equipment is necessary to permit the handling, positioning and mounting of flight hardware, the storage and transportation protection of this hardware, servicing and checkout of the completed installations, and miscellaneous other functions performed as a part of integration. Table 3-3 lists those items of equipment which have been identified and included in subsequent analyses. Items which list a drawing number are documented and described in the document "Spacelab GSE Items Descriptions Document", MSFC Drawing 40A99006 Revision A. Those items which have no drawing number have been identified as needed additional equipment. A compilation and description of all the GSE identified in this study is presented in Appendix E.

Test Requirements Identification

In the Level IV integration task, certain underlying groundrules or assumptions are used in determining the nature and extent of verification testing to be performed at the conclusion of the installation phase. Chief among these is the premise that the experiment end item equipment is received in good operating condition, completely checked out and calibrated to perform its flight mission. Verification testing, therefore, does not have to include steps to verify the performance and accuracy of the experiment - only to verify that it will function in all modes in the as-integrated configuration. These tests will verify that all electrical, mechanical and fluid interfaces which have been established during integration are functionally adequate and properly configured.

Another premise considered in verification testing is that the various experiments are joined together for the first time with the Spacelab hardware, and prior testing was incapable of determining interaction effects between experiment equipments, and between these equipments and the Spacelab subsystems. For this reason, in addition to the functional verification of each experiment individually and serially, a combined payload test is performed. In this test, the payload is operated in an abbreviated or simulated flight mode. Experiments which will be operated simultaneously in flight are operated simultaneously during the test, but for shorter durations and compatibility ascertained. Verification tests are used to check out interfaces, while functional tests are used to check out the operation of the system in the flight mode.

Another consideration in testing that is peculiar to the Space Processing Payload is the inherent nature of the melt experiments performed and the automatic self-programmed characteristics of the equipment. If commands were to be given to any of the four facilities to operate in the flight mode, even for relatively short durations, the furnaces would heat the specimens to the melting point and resolidify them as they are programmed to do in flight. This obviously would expend the flight specimens, which are installed and sealed in the equipment before Level IV integration. Therefore, in order to preclude this result and yet accomplish a meaningful interface verification, a test program was assumed to be included in the facility control system. This program, separately addressable from the Spacelab DDU/keyboard (simulated for Level IV tests), would energize the heating circuitry to a power level and temperature cutoff high enough to allow for thermocouple/pyrometer verification of appropriate temperature change, but not high enough to cause any physical/metallurgical changes in the specimens.



Table 3-3. Level IV GSE Requirements for Space Processing Payload

<u>Drawing No.</u>	<u>Nomenclature</u>
HANDLING	
612008A	Feed Through Protective Covers Kit (-01 thru -03)
612010A	Pallet Segment Floor Covers Kit (-01 thru -04)
612013A	Pallet Segment Support (-01 thru -05)
612059A	Pallet Cover (-01 and -02)
612060A	Pallet Platform
612067A	Desiccant Canister, Large (-01 thru -03)
612071A	Active Environmental Control Cart
612106A	Road Tiedown Kit, U.S.
612110A	Horizontal Sling Kit (-01 thru -03)
612113A	Trunnion Handling Fittings (-01 thru -07)
614XXX	Transportation Instrumentation
CHECKOUT	
613039	Grounding/Bonding Tester
SERVICING	
612080A	Portable Leak Detection Unit (-01 thru -05)
612084	Freon Servicer
612086	Freon Leak Detector (-01 thru -03)
612115	Refrigeration Unit
AUXILIARY	
612114A	Cleaning Kit
614022	Desiccant Drying Oven



The single pallet-only configuration of the Space Processing payload also introduces a unique testing consideration. As all of the payload equipment, Spacelab interfacing units, and servicing and checkout GSE is at one site it would be unrealistic/impractical to complete individual facility checkout at one site and then move to a second site to accomplish integrated payload checkout. Therefore, the test sequences for the distributed site option for this payload is identical to that of the lead center and KSC options.

Since the experiment end item equipment is received in good operating condition and checked out, verification tests will be conducted only to verify the functional interfaces between the experiment equipment, the common support equipment, the Spacelab pallet subsystems and the Igloo and Orbiter interfaces. Man-machine interfaces were considered in the control/display panel layouts and indicator designs, as well as in determining the time and manpower requirements of the verification steps themselves. Flight timelines were considered in the conceptual design of the combined payload tests. Tests at both experiment level and payload level were considered to be performed using flight software to accomplish software validation in conjunction with the integration interface verification. As a result of the melt experiment limitations, the full power rating with the software will not be verified during the tests.

Installation and Test Activity Assignment

The activities associated with Level IV integration of the Space Processing payload are as follows:

- (a) Installation of all experiment/facility end items (control and display panel) onto the Spacelab pallet.
- (b) Installation of all signal and power cabling on the pallet. This includes wiring interconnecting experiment end items, wiring connecting end items to pallet subsystems and wiring to pallet interface connector brackets.
- (c) Installation of all other common support equipment, limited in this case to the furnace supports, cable trays and brackets.
- (d) Temporary installation of GSE cabling, flex lines and connection to checkout and servicing GSE, involved in the verification operation.
- (e) Verification of both individual facilities and combined payload testing.
- (f) Disassembly of the temporary connections in (d), securing of experiment and subsystem equipment, and preparation for movement or shipment to the next integration site for Level III.



Integration activities not performed in Level IV include:

- (a) Installation of the EI-1 shared control/display panel onto the Orbiter Aft Flight Deck, which is performed in Level I in the Orbiter Processing Facility (OPF) at Kennedy Space Center.
- (b) Installation of the AFD cabling is performed in the OPF.
- (c) Installation of the transition cables will be accomplished at KSC during the staging activities.

Experiment Installation and Test Sequences

A pictorial representation of the progressive installation of payload equipment is shown in Figure 3-7. The steps depicted in this figure were translated into discrete tasks and time estimates established based upon the criteria defined above under Standardized Time Estimations. Standard task waterfalls were then developed for the Level IV activities. The Level IV activities for each of the four facilities of the Space Processing payload are delineated in waterfall format in Figures 3-8 through 3-11. These task schedules or waterfalls were integrated into one and the combined payload checkout was added (Figure 3-12).

In addition to the level IV activities, payload unique ground processing is required during KSC-STS operations. Payload related activities during Spacelab integration, Orbiter integration, and post-flight payload de-integration are identified in Figures 3-13, 3-14, and 3-15 respectively. Pre-flight servicing/top-off of facility gas supplies at the launch pad, and post-flight safing and removal of the payload unique AFD panels in the OPF are also required. Based upon discussions with cognizant KSC personnel, all of the identified payload related activities required during KSC-STS operations are in accordance with current planning.

An overview of the ground processing cycle for the Space Processing payload from initiation of level IV integration through post-flight payload deintegration is presented in Figure 3-16. (The number in each block refers to the activities defined in Section 2.) For this particular payload, there is no significant difference between distributed site and lead center flows, nor between functional activity block 3/4 and 5/6. Thus, the overall flow for options A-2, B-2 and B-4 are the same. The KSC options, C-2 and C-4, reflect the reduced transportation time to/from the level IV site. All other activities are the same as for the distributed and lead center options.

Summary

The installation, test, transportation, STS integration, and post-flight activities defined herein provided the basis for the development of resource requirements for the ground processing of this payload. In section 4, the manpower estimations, hardware utilizations, and costs data for this payload are developed.

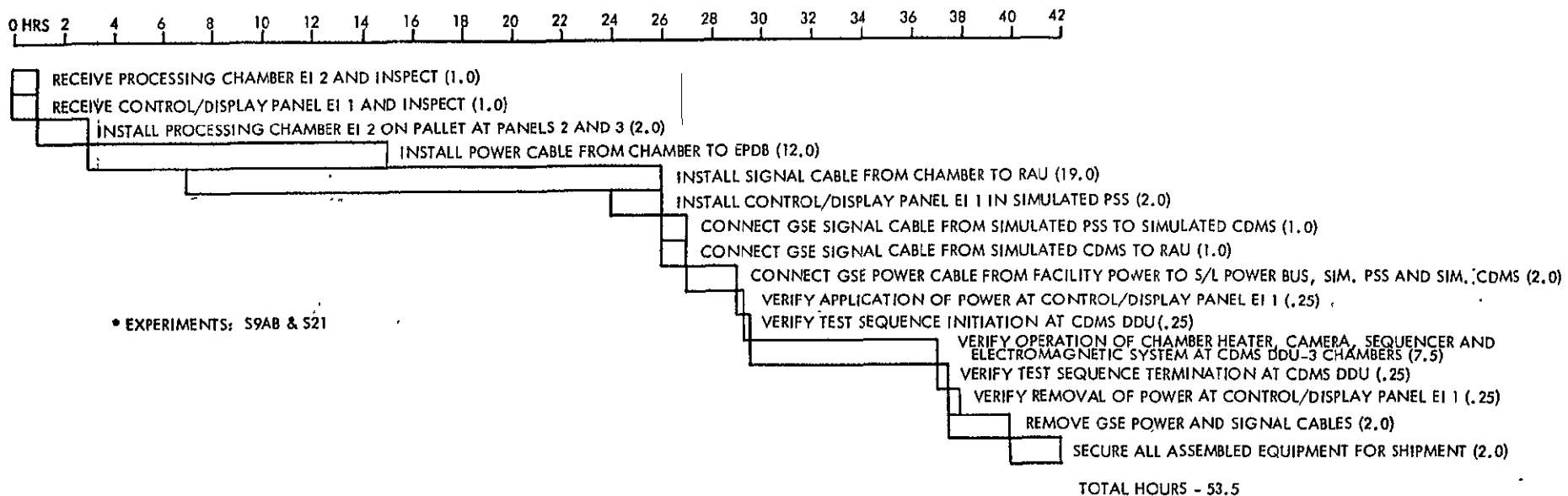


Figure 3-8, Installation & Test Timeline for the Electromagnetic Levitation Melt Facility #1

3-21

SD 78-SR-0009-2

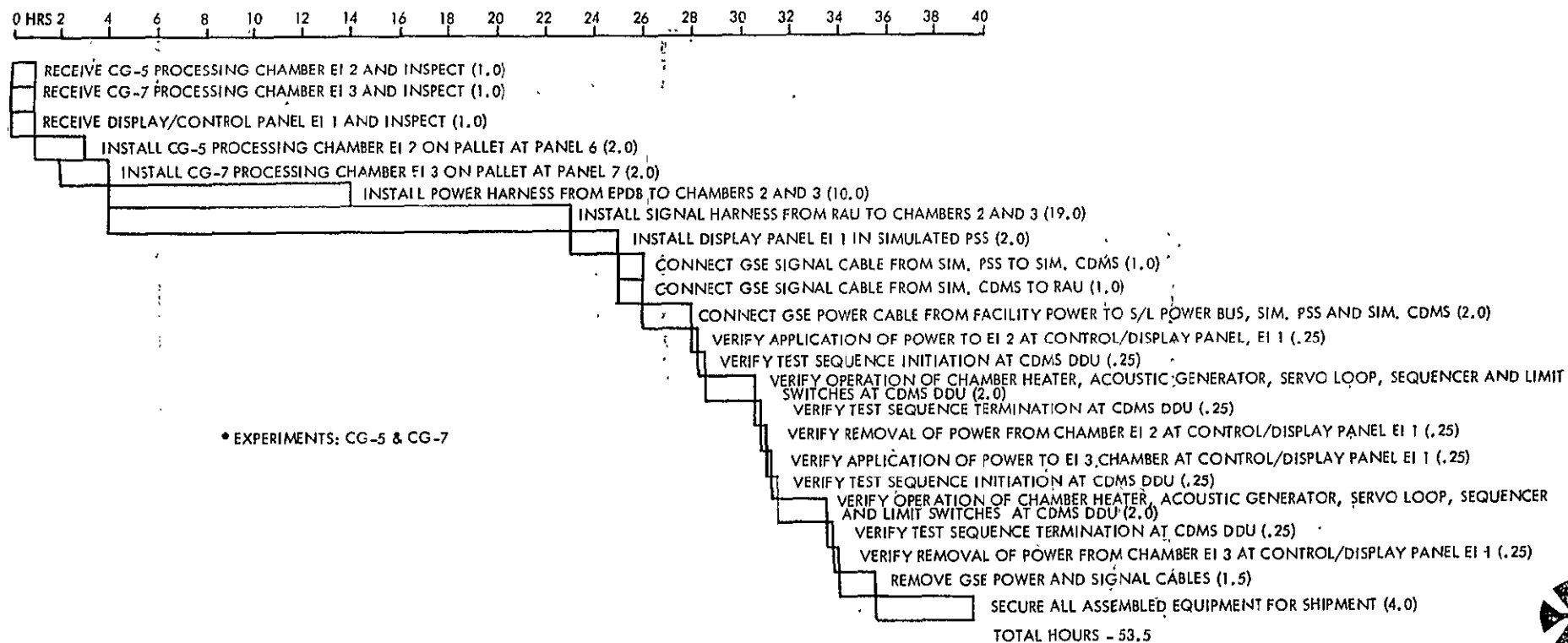


Figure 3-9, Installation & Test Timeline for the Acoustic Levitation Melt Facility #2

SPACE PROCESSING PAYLOAD - LEAD CENTER/ISC FLOW



Figure 3-12, Integrated Space Processing Payload Installation & Test Sequence

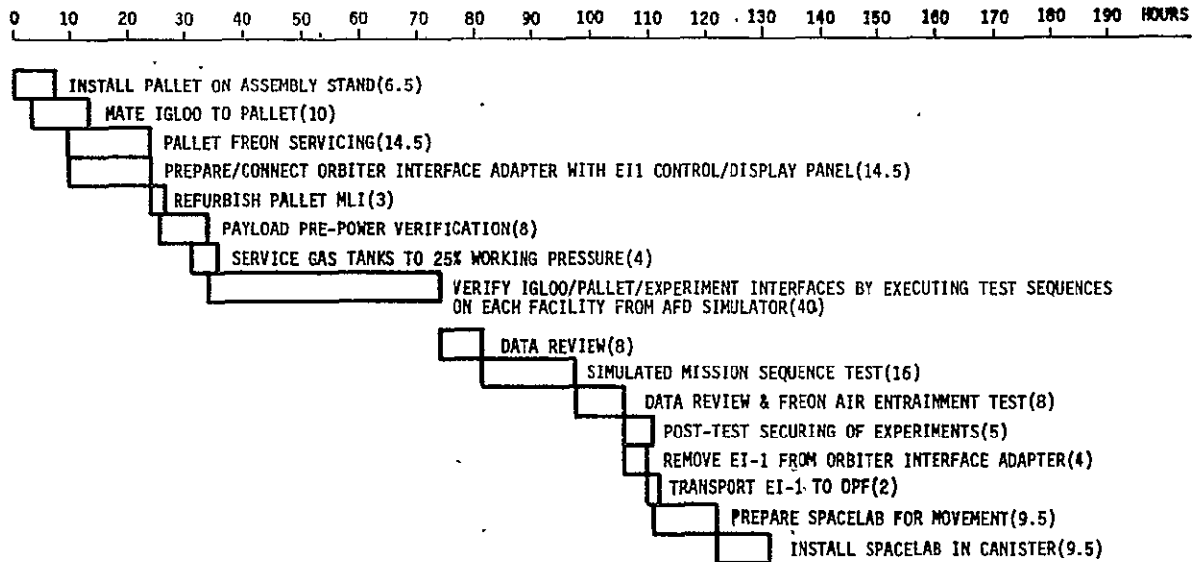


Figure 3-13, Space Processing Payload Level III/II Integration Activities

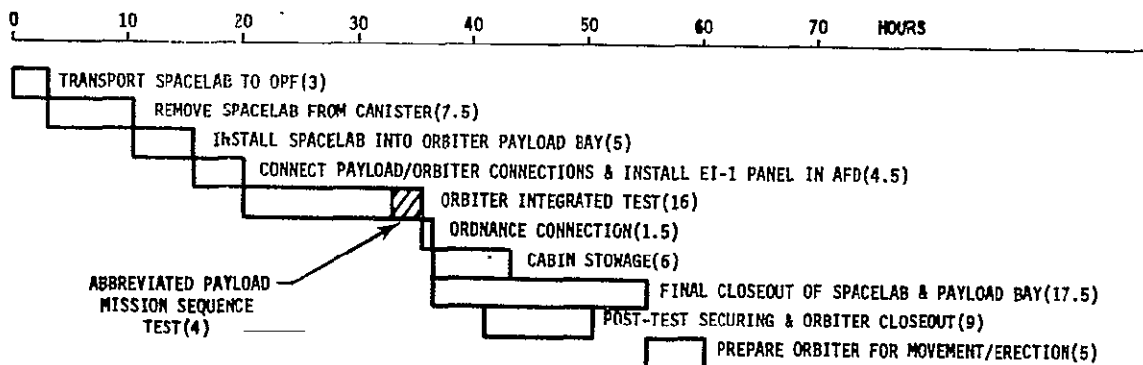


Figure 3-14, Space Processing Payload - Level I OPF Operations

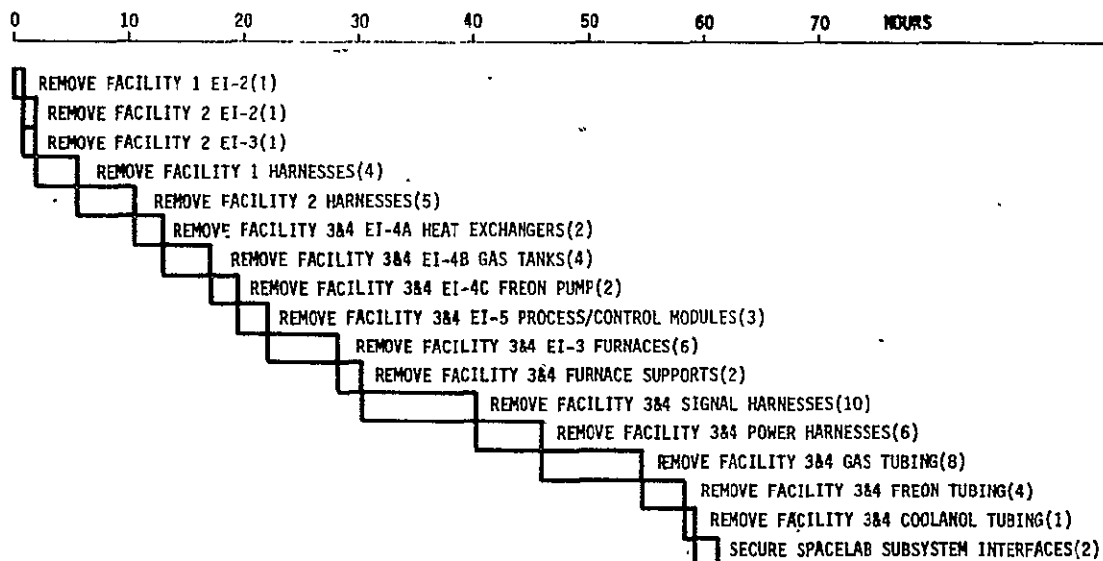


Figure 3-15, Space Processing Payload - Level IV Deintegration

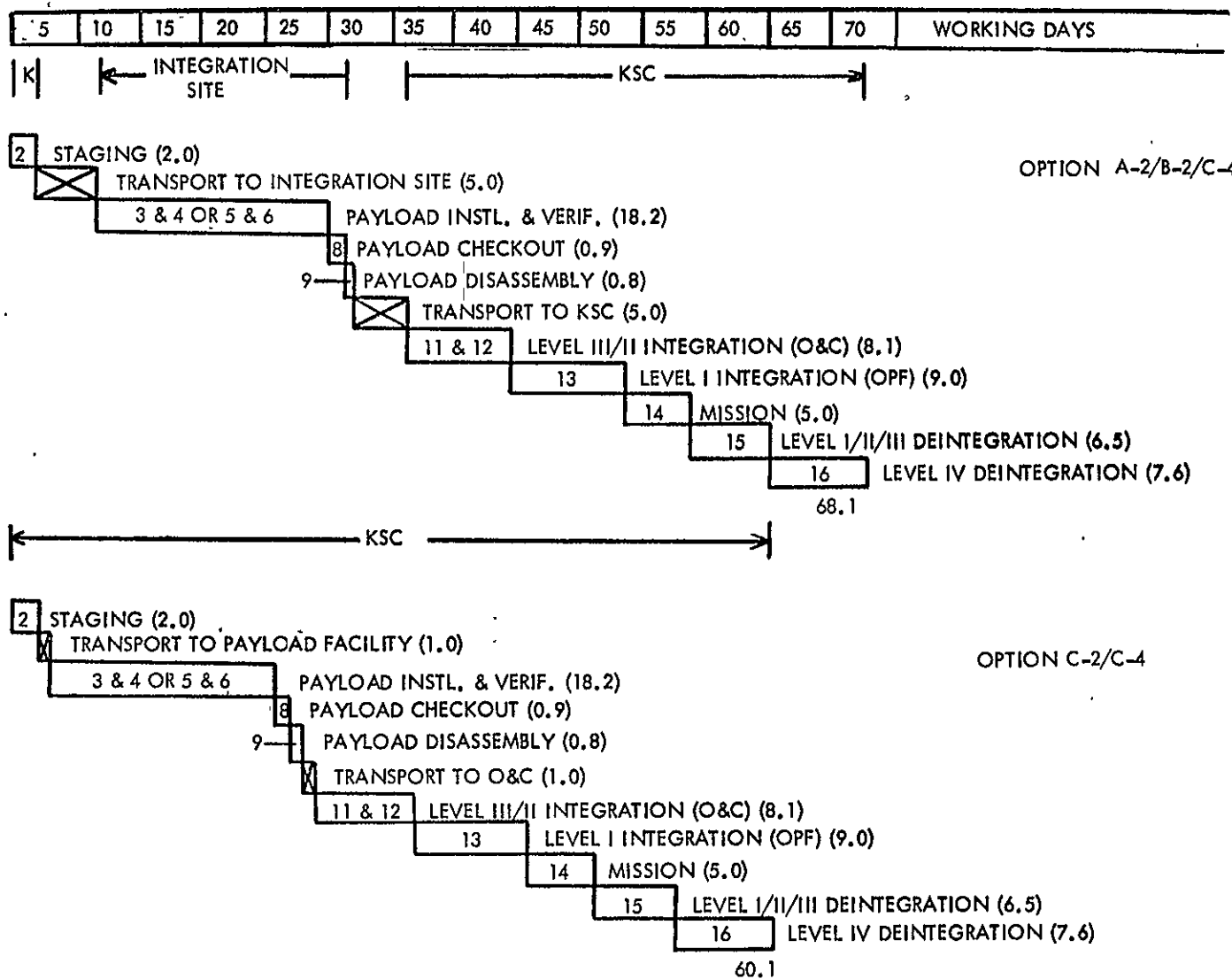


Figure 3-16. Summary of Space Processing Payload Ground Operations



COMBINED ASTRONOMY PAYLOAD INSTALLATION & TEST REQUIREMENTS

The Combined Astronomy payload used in this study consists of a five pallet, pallet-only Spacelab configuration (Figure 3-17). The lead pallet or forward complement incorporates two experiments/sensors mounted in thermal canisters and integrated with the SIPS. The mid-complement consists of the IPS mounted on one pallet and the SIRTf mounted on a two-pallet train. The gamma-ray detector assembly is mounted on the last pallet.

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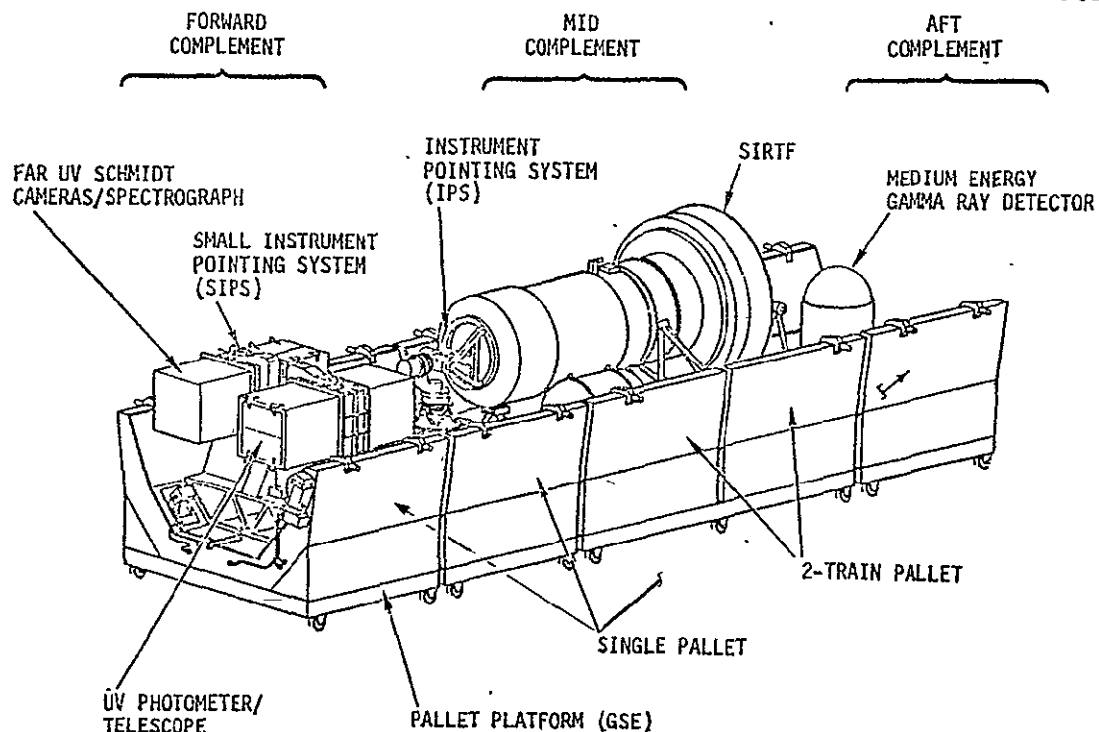


Figure 3-17. Combined Astronomy Payload

Applicable Ground Processing Options

The configuration of the Combined Astronomy payload permits decoupling of the level IV ground processing activities between the forward, mid, and aft complements of equipment. Installation and assembly operations of the equipment for each complement could readily be distributed to three geographically separated sites or independently conducted at a centralized site. Combined payload checkout prior to initiation of KSC-STs operations is also a viable option. Based upon the groundrules previously delineated for the development of study baseline data, level III assembly in the O&C building is not required. The three complements of this payload can enter KSC-STs operations in the III/II integration



main stand. Thus, the applicable ground processing options for this payload are A-2, B-2, B-4, C-2 and C-4 (reference Section 2.0). In addition, the A-1, B-1, and C-1 options are applicable if the level III O&C assembly activity (block 10) is deleted/by-passed in these three options. Baseline study data for the Combined Astronomy payload for all seven options are subsequently presented.

Installation Requirements

In the development of baseline study data, the integration of the UV and Schmidt camera sensors with the SIPS canisters was considered to be part of sensor development activities. The sensors and canisters are an integral design. It is anticipated that environmental verification testing of the sensor-canister assembly will be an essential part of the development cycle.

Level IV integration of the forward complement was considered to be initiated upon receipt of the sensor-canisters, SIPS pedestal and pallet at the integration site. It was assumed that the IPS was mounted on a pallet during staging at KSC and transported to the level IV site in that configuration. The SIRTf was considered to be a completely integrated assembly upon initiation of level IV activities. For example, the multiple instrument compartment was integrated with the telescope assembly and sealed to preclude contamination of the optics prior to level IV integration. The gamma-ray detector is also a single assembly at initiation of level IV activities. Transition cables and coolant lines across one pallet for functions on subsequent pallets were assumed to be installed during staging operations at KSC.

Experiment Equipment

The complement of experiment equipment to be installed during Combined Astronomy level IV integration is listed in Table 3-4. Only the installation of 1.0, 2.0, 3.0, and 4.0 assemblies are level IV activities. Lower indent items are for reference only and reflect the required pre-level IV integration of Combined Astronomy experiments. The control and display panel to be installed in the Orbiter AFD is shown in Figure 3-18. This panel reflects an integration of individual experiment requirements. A DDU/keyboard is required for control of the experiment equipment, data monitoring, and status analysis. Either a dedicated unit may be used or the experiment may be tied to the Orbiter DDU/keyboard. Figure 3-18 shows the integrated requirements as a point of reference.



Table 3-4. Combined Astronomy Payload Experiment Equipment

Experiment Identification	End Item Number	End Item Description
<u>AS-01-S</u>		<u>Shuttle Infrared Telescope Facility</u>
	1.0	Telescope
	1.1	Cryogenic Tank System
	1.2	Multiple Instrument Compartment
	1.2.1	Spectrograph, Grating
	1.2.2	Camera, Photometer
	1.2.3	Interferometer, Lamellar Grating
	1.2.4	Interferometer, Michelson
	1.2.5	Polarimeter
	2.0	Panel A, OAFD C&D
	3.0	Panel B, OAFD C&D
<u>UV-2</u>		<u>UV Photometer/Telescope</u>
	1.0	UV Photometer/Telescope
	1.1	Mirror
	1.2	Grating
	1.3	Channeltron
	1.4	Metal Plates
	1.5	Star Tracker
	1.6	Calibration System
	2.0	Control & Display Panel
<u>AS-05-S</u>		<u>Far UV Schmidt Camera/Spectrograph</u>
	1.0	Electronographic Camera Assembly
	1.1	Film Transport Housing
	1.2	Grating Mirror Assembly
	1.3	Corrector Assembly
	1.4	Stray Light Baffle
	2.0	Remote TV Camera
	3.0	Control and Display Panel
	4.0	GN-2 Plumbing/Tankage
<u>GR-1</u>		<u>Medium Energy Gamma Ray Detector</u>
	1.0	Gamma Ray Telescope
	1.1	Anti Coincidence Counter Dome
	1.2	Upper Spark Chamber Array
	1.3	Lower Spark Chamber Array
	1.4	Time & Flight Scintillators
	1.5	Total Absorption Shower Counter
	2.0	Control and Display Panel

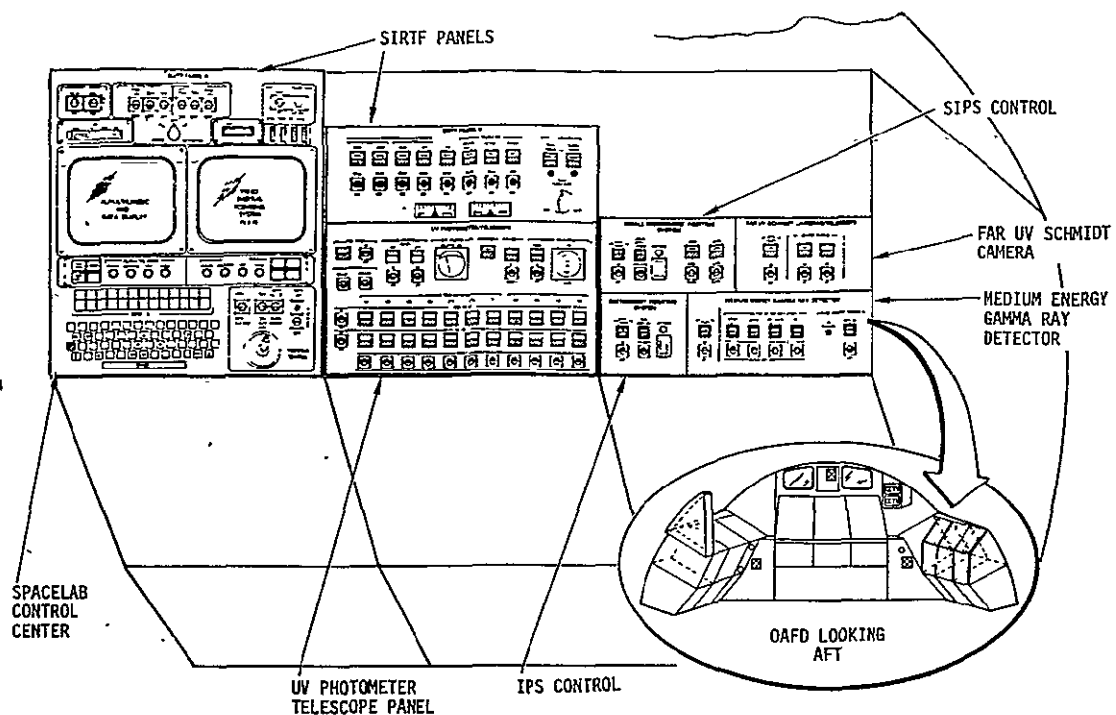


Figure 3-18.. Orbiter Aft Flight Deck Arrangement for Combined Astronomy Payload

Common Support Equipment

Equipment in this category consists of interfacing hardware between experiment equipment and Spacelab equipment. For the Combined Astronomy payload, this equipment consists of the SIPS (mounted on the lead pallet), and interconnecting cables, and coolant lines on each complement.

Spacelab-Unique Equipment

Standard Spacelab-payload interfacing equipment required by the Combined Astronomy payload is listed in Table 3-5. Spacelab subsystems equipment such as the CDMS and the high data rate multiplexer/recorder are not included. These items will remain at KSC and, if required, simulated during level IV integration activities.

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Table 3-5. Combined Astronomy Payload Spacelab Support Equipment

Spacelab Unique Equipment	AFD	Forward Complement	Mid Complement	Aft Complement	Total
Pallet, Single	-	1	1	1	3
Pallet, 2-Train	-	-	1	-	1
Freon Pump	-	1	-	-	1
Coolant Lines	-	7	8	2	17
Cold Plates	-	4	2	1	7
RAU	1	1	1	1	4
Experiment Power Dist. Box	-	1	2	1	4
Interconnect Station	-	2	2	1	5
Inverter	-	1	-	-	1
Instrument Pointing System	-	-	1	-	1

Special Handling, Checkout, Servicing and Auxiliary Ground Equipment

In addition to the flight equipment installed on the pallet in the process of Level IV integration, a complement of ground equipment is necessary to permit the handling, positioning and mounting of flight hardware, the storage and transportation protection of this hardware, servicing and checkout of the completed installations, and miscellaneous other functions performed as part of integration. Table 3-6 lists equipment which have been identified and included in subsequent analyses. Items which list a drawing number are documented and described in the document "Spacelab GSE Items Descriptions Document", MSFC Drawing 40A99006 Revision A. Items without a drawing number were identified as needed additional equipment. A compendium of all GSE identified in this study is presented in Appendix E.

Test Requirements Identification

Basic assumptions/groundrules were established in the development of the test requirements for the processing of the Combined Astronomy payload. The more significant groundrules that were used are presented herein.



Table 3-6. - Special Handling, Checkout, Servicing and Auxiliary Ground Equipment

Dwg No	Equipment Item	Dwg No	Equipment Item
	<u>HANDLING</u>		<u>SERVICING</u>
612006	Vertical Sling Kit	612080	Portable Leak Detector
612008	Feed Thru Protective Covers	612084	Freon Servicer
612010	Pallet Segment Floor Covers	612086	Freon Leak Detector
612013	Pallet Segment Support	612115	Refrigeration Unit
612059	Pallet Cover	612XXX	Vacuum Pumping Unit
612060	Pallet Platform		<u>AUXILIARY</u>
612065	Single Rack Hndlg & Transport Kit	612114	Cleaning Kit
612067	Desiccant Canister - Large	614022	Desiccant Drying Oven
612071	Active Environmental Central Cart		<u>PALLET HARDWARE</u>
612106	Road Transport Tie Down Kit		Bare Pallet Segment
612110	Horizontal Sling Kit		EPDB
612113	Trunnion Handling Fittings		Cold Plates
614XXX	Transportation Instrumentation		RAU
	<u>CHECKOUT</u>		Interconnect Station
612040	Optical Alignment Kit		Inverter
612208	IPS Test and Checkout Kit		Freon Pump Package
613038	Continuity Tester		IPS
613039	Grounding/Bonding Tester		SIPS

Note: See Appendix E for GSE physical and functional characteristics.



Pre-Level IV Sensor-Canister Integration

In general, the SIPS will be shared by two experiment/sensor systems. Each system will be housed in an environmental controlled canister for ground processing as well as in-orbit thermal protection. In addition, the alignment between the sensors and the canister structural assembly will usually be critical. Therefore, installation/integration/test of the sensor-canister assembly will be conducted at the sensor manufacturer's site or the PI's laboratory. These activities will usually be performed in a rigidly controlled environment. Upon completion of the pre-level IV activity, the canister will be used as a sealed container during subsequent shipment and processing activities to preclude contamination of the sensor. Thus, sensor-canister level IV test activities will be limited to verification of alignment of the canisters in the SIPS yoke, and verification of canister-sensor electrical interfaces with external command/control/data processing equipments.

Equipment Status at Initiation of Level IV Integration

All equipment (Spacelab, common support, experiment, and GSE) is assumed to be operational and within performance limits at the start of level IV integration activities. Receiving and inspection activities prior to level IV are limited to assessment of physical condition and transportation monitors. If functional tests are required/desired at the level IV site, they must be accomplished prior to and off-line from level IV activities.

Level IV Functional Testing

Only those functional tests necessary to verify level IV assembly/installation will be performed. If a functional check is necessary to verify a signal routing and the sensor cannot be operated, a "signal-received" response will be necessary. For example, verification of the SIRTf telescope hatch operation must be made; however, the sensitivity of the SIRTf sensors and mirrors to contamination is very critical and the telescope will not be exposed to the atmosphere during level IV integration. Therefore, either a temporary function simulator must be installed or a circuit built into the flight system. Similarly, the canisters housing the UV and Schmidt camera systems will not be opened during level IV integration.

Experiment equipment activation will occur only if required to verify an interface established in level IV integration. An assessment of the experiment system of the Combined Astronomy payload indicated that a complete activation of the experiment equipment complements was not required. Consequently, no requirements exist for liquid cryogenics or exotic gases in Level IV. Neither is there a need for the inclusion of source stimuli to check the sensor response or calibration.

SIPS and IPS Operations

Both the SIPS and IPS are designed for zero g operations. Neither of these systems will be exercised during level IV integration to assess mechanical operations. Command/control/data processing interfaces will be verified in a static mode of operation.



Software Validation

The Spacelab configuration coupled with the assembly concept of the Combined Astronomy experiment complement minimizes the mechanical interactions. However, a major potential interaction will occur in command/control/monitor functions. Experiment and SIPS/IPS operations will make extensive use of the CDMS computer/DDU/keyboard. Therefore, experiment system flight software will be verified during level IV integration using a simulated CDMS. It is recognized that certain functions/responses that are required to close the command/control loops will not be available during level IV testing. Therefore, simulated responses must be introduced into the CDMS to verify system software. It was assumed that these simulated responses would be furnished by the STS for SIPS and IPS functions and by the experimenters for the sensors/experiments. This software to simulate responses is required to verify/validate SIPS and IPS performance before assignment to a payload. Similarly the required experiment/sensor simulation software is required for performance/specification/acceptance testing of equipments prior to level IV activities.

Assembly Procedure

The assembly procedure for the Combined Astronomy payload is a relatively straight forward process of installing experiment end items on Spacelab interfacing elements to form an integrated payload. The procedure is the same whether a distributed site, central site, or KSC location is used. The basic procedure remains unchanged whether an individual experiment or a complete payload is processed. The buildup sequence of the Combined Astronomy payload is illustrated in Figure 3-19. The sequence is applicable for all viable ground processing options except for the combined payload activities (activity blocks 7,8,9) which are not part of the A-1, B-1, and C-1 options. In the case of the distributed site, the buildup of each of the three payload complements would be conducted at geographically separated sites. For lead center and KSC options, these same activities could be conducted either in separate areas or in one central area at the integration site.

Receiving Inspection

Every item of equipment will receive incoming inspection. Physical as well as transportation monitor (temperature, humidity, acceleration, etc.) assessment will be conducted. A specific time allocation for inspection of experiment equipment was not developed. Experiment equipment inspection was assumed to occur in time to support installation in/on Spacelab mounting elements. However, Spacelab equipment receiving/inspection was specifically considered.

Forward Complement Buildup

After removal of the pallet cover (612059A), the single forward pallet is inspected for damage and positioned in its checkout location. Since the pallet has arrived from the staging area, all appropriate spacelab systems will have been installed. These consist of coldplates, EPDB, RAU, plumbing and appropriate hardware, and transition cables and



fluid lines for subsequent pallet functions.

The SIPS pedestal is processed and mounted onto the forward pallet. A SIPS-unique sling is used in conjunction with an overhead crane to position the SIPS pedestal onto the pallet. Precision alignment with the pallet is obtained by using the Optical Alignment Kit (612040).

Both the UV Photometer and Schmidt cameras, mounted in their respective canisters, are brought to the pedestal for installation in the yokes using unique slings in conjunction with an overhead crane. Precise alignment of canister-to-yoke is required since pointing and attitude relationships are critical in target selection, location and tracking. The optical alignment kit (612040) is used to aid in the alignment procedure.

Following the mechanical installation of the SIPS pedestal and canisters, all appropriate harnesses and remaining support equipment are installed. Interface verification tests are then conducted. At this juncture, the forward complement may be prepared for transport or it may remain in a quiescent state until the other payload complements are assembled and then interconnected for combined payload checkout. If the complement is to remain quiescent, appropriate ground support equipment (i.e. gaseous nitrogen purge cart) is attached and monitored as required. If the complement is to be immediately processed for transportation, appropriate packaging and shipping operations are conducted. Shipment times were included in the appropriate ground processing flows.

Mid Complement Buildup

In this buildup sequence, the single pallet containing the pre-installed IPS is processed through the inspection procedure. The pallet cover (612059A) is removed and stored and the pallet/IPS are inspected for damage. The pallet and platform (612060A) are positioned for integration with the SIRTf and its two pallet train. The IPS pallet and the SIRTf two-pallet train were staged at KSC and included RAU's, coldplates, EPDB's, and the transition cables for function on the subsequent pallets. In case of a requirement to remove or reposition the IPS, the IPS handling kit (612210) and IPS transportation kit (612209) were included in the GSE complement.

This baseline approach is predicated upon the availability of the IPS during level IV integration. If the IPS were not available, then the entire pallet could be replaced by substituting appropriate electronic/electrical and mechanical interfaces. Specifically, a single RAU would be used to interface with the electronic components of the telescope. A substitute IPS "black box" would be required for the IPS interface functions. The electrical and mechanical interfaces between pallets would also be simulated by GSE cable sets.

Receiving inspection of the two-train pallet occurs simultaneously with the IPS pallet. The pallet cover (612059A) is removed, the pallet train is inspected and placed into position behind the IPS pallet using the two-train pallet vertical sling kit (612006A) and an overhead crane.

The SIRTf arrives as an already assembled unit consisting of the MIC, telescope, cryogenic system, telescope hatch and launch support structure mounted to some type of strongback transporter. The system includes a vacuum pump to maintain an internal telescope vacuum to prevent contamination. The transportation instrumentation (614XXX) record is removed and checked for any out of tolerance conditions the unit may have experienced. If none are found, the SIRTf is inspected for visible damage then lifted via the SIRTf unique sling and facility crane and placed into the two-train pallet. With the aid of the Optical Alignment Kit (612040) and mechanical tools, the unit is installed onto the pallets and secured.

Aft Complement

The aft complement is the least complicated system of the Combined Astronomy payload. The aft pallet arrives with coldplate, plumbing and basic harness installed. The receiving inspection and positioning is similar to that described for the other single pallets. Similarly the medium energy gamma-ray detector is processed through the receiving inspection and placed onto the aft complement pallet with the aid of the Optical Alignment Kit (612040).

Installation and Test Sequences

Step-by-step sequences of installation and test activities were developed for the level IV integration of the Combined Astronomy payload for the applicable ground processing options. The sequences for the A-1, B-1 and C-1 options were identical. Three separate sequences of activities corresponding to the three complements of the payload were prepared (Figures 3-20, 3-21, and 3-22). For the A-1 option, the sequences would be conducted at three geographically separated locations and require a full complement of GSE at each site. In the B-1 and C-1 options, the same three sequences are applicable. Appropriate scheduling/staggering of operations will permit sharing of certain items of GSE even though the three sequences are conducted separately.

The sequences for the A-2, B-2, and C-2 level IV integration activities are also identical. Transportation between activities and the location of the activity vary between options but the basic tasks are the same. In essence, the three sequences for the A-1, B-1 and C-1 are conducted and then integrated payload checkout (prior to KSC-STS) operations is conducted. These integrated payload activities (which correspond to functional blocks 7, 8 and 9 as defined in Section 2) are delineated in Figure 3-23.

In the B-4 and C-4 options, the assembly and checkout is conducted at the integrated payload level. The sequences for these two options are also identical (Figure 3-24). This sequence reflects the integration of the activities of the three complements of the payload and certain efficiencies that can be achieved by the minimizing of equipment moves and GSE connect/disconnect activities.



Figure 3-20. Forward Complement Installation and Test Sequence



Figure 3-21. Mid-Complement Installation and Test Sequence

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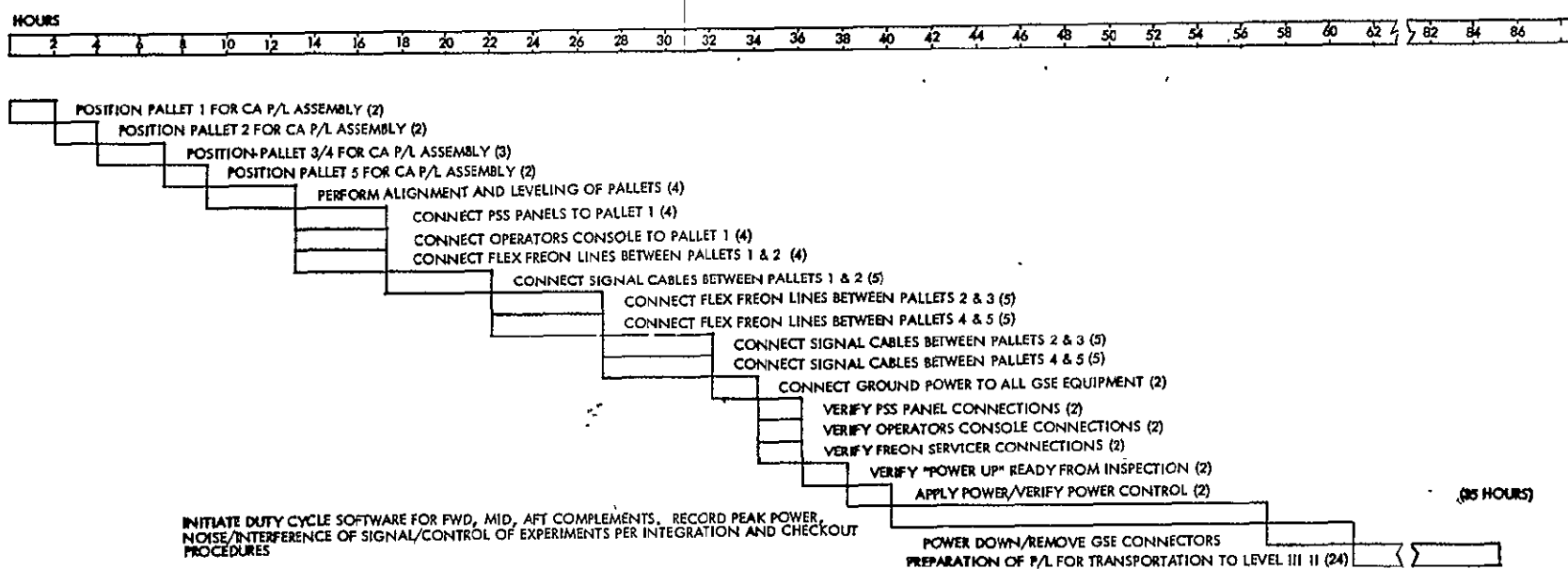
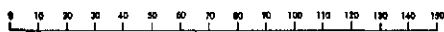


Figure 3-23. Combined Payload Assembly and Checkout Sequence



POULDOUT FRAME

- RECEIVE SPACELAB FLIGHT EQUIPMENT WITH SUBSYSTEMS INSTALLED; EXPERIMENT FLIGHT EQUIPMENT, CONSOLES, AND SPACELAB/EXPERIMENT/CONSOLE/INTERFACE & COMMON GSE
- TRANSPORT ALL EQUIPMENT TO LEVEL IV WORK AREA OR TO STORAGE AREA (S)
- PERFORM RECEIVING INSPECTION ON ALL EQUIPMENT EXCEPT THE SHUTTLE INFRARED TELESCOPE FACILITY (SIRTF) AND THE MEDIUM ENERGY GAMMA RAY DETECTOR (MEGRD) (4)
- INSTALL SIRTF PANEL "A" ON THE PSS PANEL RACK (3)
- INSTALL SIRTF PANEL "B" ON THE PSS PANEL RACK (4)
- INSTALL UV PHOTOCHAMBER/TELESCOPE (UV/PT) PANEL IN THE PSS PANEL RACK (5)
- INSTALL SMALL INSTRUMENT POINTING SYSTEM (SIPS) PANEL IN THE PSS PANEL RACK (6)
- INSTALL FAR UV SCHMIDT CAMERA/TELESCOPE PANEL IN THE PSS PANEL RACK (5)
- INSTALL INSTRUMENT POINTING SYSTEM (IPS) PANEL IN PSS PANEL RACK (4)
- INSTALL MGRD PANEL IN PSS PANEL RACK (5)
- CONNECT PSS PANELS TO C87 AT PORT LEADING EDGE OF PALLET #1 (DIRECT SIGNAL CABLES) & TO OPERATORS CONSOLE (S/S & EXPERIMENT S/S UNITS) (4)
- CONNECT OPERATORS CONSOLE TO C81 AT STARBOARD LEADING EDGE OF PALLET #1 (4)
- CONNECT GSE FLEX FROM LINES TO THE S/S FROM LOOP BETWEEN PALLETS #1 & #2 (5)
- CONNECT GSE SIGNAL CABLES BETWEEN PALLETS #1 & #2 (5)
- CONNECT FROM SERVER (SIRFAS) TO RETROREFLECTION UNIT (R1B1B1A) & TO S/S FROM LOOP Q2/Q4 AT THE 1/2 CONNECTOR BRACKET ON PORT LEADING EDGE OF PALLET #1. CONNECT SPSR UNIT TO FACILITY HALL SERVICE S/S FROM SYSTEM (14)
- CONNECT GSE FLEX FROM LINES TO THE S/S FROM LOOP BETWEEN PALLETS #2 & #3 (5)
- CONNECT GSE SIGNAL CABLES BETWEEN PALLETS #2 & #3 (5)
- CONNECT GSE SIGNAL CABLES BETWEEN PALLETS #2 & #3 (5)
- CONNECT GROUND POWER CABLE TO PERIPHERAL EQUIPMENT CONSOLE, TO OPERATORS CONSOLE, TO PSS PANELS, & TO GROUND POWER SOURCE, COMMAND SPACELAB SUBSYSTEMS "ON" AT THE PERIPHERAL EQUIPMENT CONSOLE (5)

- PALLET #1
 - LOCATE PALLET #1 IN ITS PALLET INTEGRATION POSITION
 - HOST SPS TO PALLET #1 AND LOCATE IN POSITION (4)
 - PERFORM ALIGNMENT OF SPS AND TORQUE ATTACH BOLTS TO PALLET #1 PER INSTALLATION DRAWING (5)
 - INSTALL HARNESS CONTAINING PC-1 (AC), PC-2 (DC), SC-1, SC-2, AND SC-18 BETWEEN THE SPS CONTROL ELECTRONICS UNIT & THE EPS, PALLET #1 (PC-1 & PC-2) THE EXPERIMENT BAU (SC-18 - SPS CONTROL), THE EXPERIMENT INTERCONNECTING STATION (S) (SC-1-SCHMIDT CONTROL/DATA), SC-3 - UV/PT CONTROL/DATA (5)
 - INSTALL UV/PT CANISTER ON THE SPS (5)
 - INSTALL FAR UV SCHMIDT CAMERA/TELESCOPE CANISTER ON THE SPS (5)
 - CONNECT O₂ SOURCE TO O₂ IN BOTH CANISTERS (5)

- PALLET #2
 - LOCATE PALLET #2 IN ITS PALLET INTEGRATION POSITION
 - INSTALL HARNESS CONTAINING SC-4A, SC-7A & SC-8A BETWEEN C83, PALLET #2, & THE IPS BASE CONNECTOR BRACKET (C81) (4)
 - INSTALL HARNESS CONTAINING PC-3A, & PC-4A BETWEEN EPSR, PALLET #2 AND THE IPS BASE (5)

- PALLET #3/4
 - PERFORM RECEIVING INSPECTION OF SIRTF EQUIPMENT - VERIFY TELESCOPE IS EVACUATED (15)
 - LOCATE PALLET #3/4 IN THEIR PALLET INTEGRATION POSITION
 - INSTALL HARNESS CONTAINING SC-3, SC-4, SC-5, PC-18, & PC-19 BETWEEN THE HIC & THE IPS/SIRTF 1/2 RING C3 - (STOW HIC END FOR LATER CONNECTIONS) (4)
 - INSTALL HARNESS CONTAINING PC-7B & PC-8 BETWEEN THE CARBOGEN TANK HEATER & THE IPS/SIRTF 1/2 RING C3 - (STOW HEATER END FOR LATER CONNECTIONS) (5)
 - INSTALL HARNESS CONTAINING SC-4B & PC-9 BETWEEN THE SUNSHADE ACTUATOR & THE IPS/SIRTF 1/2 RING C3 - (STOW SUNSHADE END FOR LATER CONNECTIONS) (15)
 - INSTALL HARNESS CONTAINING SC-4 (SIPS) & SC-10 (REMAINING 12 HRS) BETWEEN C83, PALLET #2 & THE SIRTF ATTACH TRUNKING POWER/SIGNAL DISTRIBUTION BOX (SC-4) AND THE SIRTF COVER ACTUATORS (SC-10 - STOW DISTRIBUTION BOX & COVER ENDS FOR LATER CONNECTIONS) (5)
 - INSTALL PC-7 BETWEEN EPSR, PALLET #4, AND THE SIRTF COVER ACTUATORS - (STOW COVER END FOR LATER CONNECTIONS) (15)
 - INSTALL PC-7 BETWEEN EPSR, PALLET #4, AND THE SIRTF COVER ACTUATORS - (STOW COVER END FOR LATER CONNECTIONS) (15)
 - HOST SIRTF TO PALLET #3/4 & LOCATE IN POSITION (4)
 - PERFORM ALIGNMENT OF SIRTF & TORQUE ATTACH BOLTS TO PALLET #3/4 PER INSTALLATION DRAWING (5)
 - CONNECT GROUND POWER CABLE TO SIRTF EXTERNAL POWER RECEPTACLE (FOR VACUUM PUMP) (1)
 - CONNECT ALL CONNECTORS LEFT STOWED PRIOR TO SIRTF INSTALLATION (5)

- PALLET #6
 - PERFORM RECEIVING INSPECTION OF MEGRD EQUIPMENT (14)
 - LOCATE PALLET #6 IN ITS PALLET INTEGRATION POSITION
 - INSTALL HARNESS CONTAINING SC-11 & PC-9 BETWEEN EXPERIMENT BAU, PALLET #5 (PC-11), & EPSR, PALLET #5 (PC-9), & THE MEGRD - (STOW MEGRD ENDS FOR LATER CONNECTIONS) (5)
 - HOST MEGRD TO PALLET #5 & LOCATE IN POSITION (4)
 - PERFORM ALIGNMENT OF MEGRD & TORQUE ATTACH BOLTS TO PALLET #5 PER INSTALLATION DRAWING (4)
 - CONNECT SC-11 & PC-9 CONNECTORS TO THE MEGRD (5)

- ☐ VERIFY LEVEL IV INSTALLATIONS OF THE UV/PT & FAR UV SCHMIDT CAMERA/TELESCOPE EXPERIMENTS USING PSS PANEL BACK (5)
 - a. SPS MAIN POWER CONTROL FUNCTION ON/OFF
 - b. CANISTER LAUNCH/ENTRY LATCH OPERATION
 - c. SPS OPERATION ABOUT Z AXIS
 - d. SPS OPERATION ABOUT Y AXIS
 - e. CANISTERS ABOUT YOKE Z AXIS
 - f. JETISON CIRCUIT INTEGRITY
 - g. CANISTER "A" PURGE PRESSURE
 - h. SPS SCHMIDT CAMERA DOOR OPEN/CLOSE FUNCTION
 - i. SCHMIDT SYSTEM MAIN POWER ON/OFF FUNCTION
 - j. SCHMIDT SYSTEM CAMERA 1 & 2 ON/OFF FUNCTION
 - k. SCHMIDT SYSTEM TV CAMERAS OPERATING FUNCTION
 - l. SCHMIDT SYSTEM FILM ADVANCE OPERATION
 - m. SCHMIDT SYSTEM DATA RETURN
 - n. CANISTER "B" PURGE PRESSURE
 - o. PHOTOCHAMBER MAIN POWER ON/OFF CONTROL FUNCTION
 - p. CHANNELTRONS (C1 TO C7) & PHOTOCHAMBER (PM-1 TO PM-4) LOW VOLTAGE ON/OFF
 - q. CHANNELTRONS (C1-1 TO C1-7) & PHOTOCHAMBER (PM-1 TO PM-4) LOW VOLTAGE ON/OFF
 - r. PHOTOCHAMBER MODE CONTROL LOCAL/REMOTE
 - s. PHOTOCHAMBER CALIBRATION SOURCE C1 & IN/OUT
 - t. PHOTOCHAMBER COMMAND ENABLE/EXECUTE
 - u. PHOTOCHAMBER STAR PRESENCE RELATIVE MAGNITUDE METER
 - v. PHOTOCHAMBER TRACKER LOCK ON/OFF
 - w. PHOTOCHAMBER DETECTOR MALFUNCTION POWER ON/OFF
 - x. PHOTOCHAMBER DETECTOR MALFUNCTION AUDIO SELF/TOY
 - y. PHOTOCHAMBER OPERATION CONTROL FUNCTION

- ☐ VERIFY LEVEL IV INSTALLATIONS OF THE SIRTF EXPERIMENT USING THE PSS PANELS (16)
 - a. SIRTF PANELS ARE MAIN POWER CONTROL
 - b. IPS MAIN POWER CONTROL
 - c. PHOTOCHAMBER AT SIRTF
 - d. TELECHAMBER TELECHAMBER ATTITUDE RECEIVED AT SIRTF
 - e. TELECHAMBER TELECHAMBER ATTITUDE LATCHES (SIMULATED)
 - f. TELECHAMBER TELECHAMBER ATTITUDE LATCHES (SIMULATED)
 - g. TELECHAMBER TELECHAMBER ATTITUDE LATCHES (SIMULATED)
 - h. TELECHAMBER TELECHAMBER ATTITUDE LATCHES (SIMULATED)
 - i. TELECHAMBER TELECHAMBER ATTITUDE LATCHES (SIMULATED)
 - j. TELECHAMBER TELECHAMBER ATTITUDE LATCHES (SIMULATED)
 - k. TELECHAMBER TELECHAMBER ATTITUDE LATCHES (SIMULATED)
 - l. TELECHAMBER TELECHAMBER ATTITUDE LATCHES (SIMULATED)
 - m. TELECHAMBER TELECHAMBER ATTITUDE LATCHES (SIMULATED)
 - n. TELECHAMBER TELECHAMBER ATTITUDE LATCHES (SIMULATED)
 - o. TELECHAMBER TELECHAMBER ATTITUDE LATCHES (SIMULATED)
 - p. TELECHAMBER TELECHAMBER ATTITUDE LATCHES (SIMULATED)
 - q. TELECHAMBER TELECHAMBER ATTITUDE LATCHES (SIMULATED)
 - r. TELECHAMBER TELECHAMBER ATTITUDE LATCHES (SIMULATED)
 - s. TELECHAMBER TELECHAMBER ATTITUDE LATCHES (SIMULATED)
 - t. TELECHAMBER TELECHAMBER ATTITUDE LATCHES (SIMULATED)
 - u. TELECHAMBER TELECHAMBER ATTITUDE LATCHES (SIMULATED)
 - v. TELECHAMBER TELECHAMBER ATTITUDE LATCHES (SIMULATED)
 - w. TELECHAMBER TELECHAMBER ATTITUDE LATCHES (SIMULATED)
 - x. TELECHAMBER TELECHAMBER ATTITUDE LATCHES (SIMULATED)
 - y. TELECHAMBER TELECHAMBER ATTITUDE LATCHES (SIMULATED)
 - z. TELECHAMBER TELECHAMBER ATTITUDE LATCHES (SIMULATED)

- ☐ VERIFY LEVEL IV INSTALLATIONS OF THE MEGRD EXPERIMENT USING THE PSS PANEL BACK (5)
 - a. COMMAND & DISPLAY PANEL POWER CONTROL FUNCTION
 - b. POWER TO EXPERIMENT ON/OFF CONTROL FUNCTION
 - c. HIGH VOLTAGE UPPER LOWER SPARK CHAMBER CONTROL FUNCTION & POWER VOLTAGE AT EXPERIMENT
 - d. TIME OF FLIGHT FUNCTION
 - e. SPARK CHAMBER GAS PRESSURE CONTROL & DISPLAY FUNCTION
 - f. CRT & KEYBOARD FUNCTION & DISPLAY FOR ITEMS 1 THROUGH 5

- ☐ COMMAND SPACELAB SUBSYSTEMS "OFF" AT THE PERIPHERAL EQUIPMENT CONSOLE & DISCONNECT ALL GSE CABLES & FLEX LINES (17)
- ☐ REMOVE ALL CONTROL & DISPLAY PANELS FROM THE PSS PANEL BACK & SECURE PANELS FOR SHIPMENT (2)
- ☐ SECURE PALLET #1 FOR SHIPMENT (4)
- ☐ SECURE PALLET #5 FOR SHIPMENT (4)
- ☐ SECURE PALLETS #2 & #3/4 FOR SHIPMENT (5)

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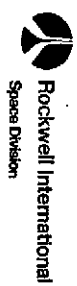
Figure 3-24. Combined Astronomy - Integrated Payload Assembly and Checkout

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POULDOUT FRAME





In addition to the basic level IV integration activities, payload related tasks during level III/II and I integration were identified. Level III/II tasks are summarized in Figure 3-25. It is recognized that these tasks are only a small part of the total III/II integration activity. However, based upon an assessment of the currently available III/II planning data, these tasks can be accomplished within the allocated time for payload related work.

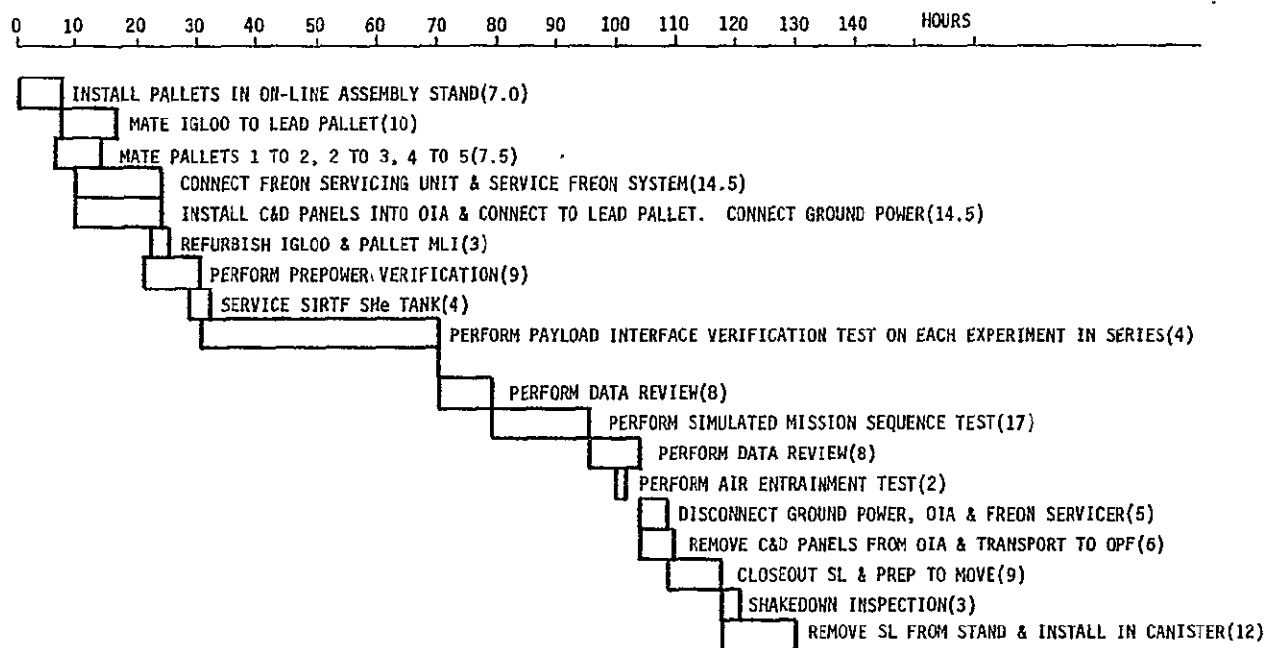


Figure 3-25. Combined Astronomy Payload Level III/II Integration

Installation of the Combined Astronomy payload into the Orbiter requires no unique activities. AFD control panel installation as well as pallet train/segment installation can be accommodated in the currently allocated time.

On-pad operations for this payload are also compatible with current allocations. However, the operations are rather extensive because of pre-launch servicing requirements. Both the far UV Schmidt Camera/Spectrograph and the UV Photometer Telescope require GN-2 purge tank filling and the Schmidt camera must be loaded with film. The medium energy Gamma-Ray detector requires a check to determine if a top off is necessary of the Neon tank. The SIRTf has the requirement to pre-chill, fill and top off the cryogenic system prior to launch.

The use of supercritical helium in SIRTf requires substantial pre-launch preparation. A nominal timeline of activities is shown in Figure 3-26. Approximately 70 to 80 hours prior to launch the cooling system is evacuated to remove any traces of contamination



which may freeze block coolant flow. The system preparation, evacuation and checkout requires approximately 30 hours to perform.

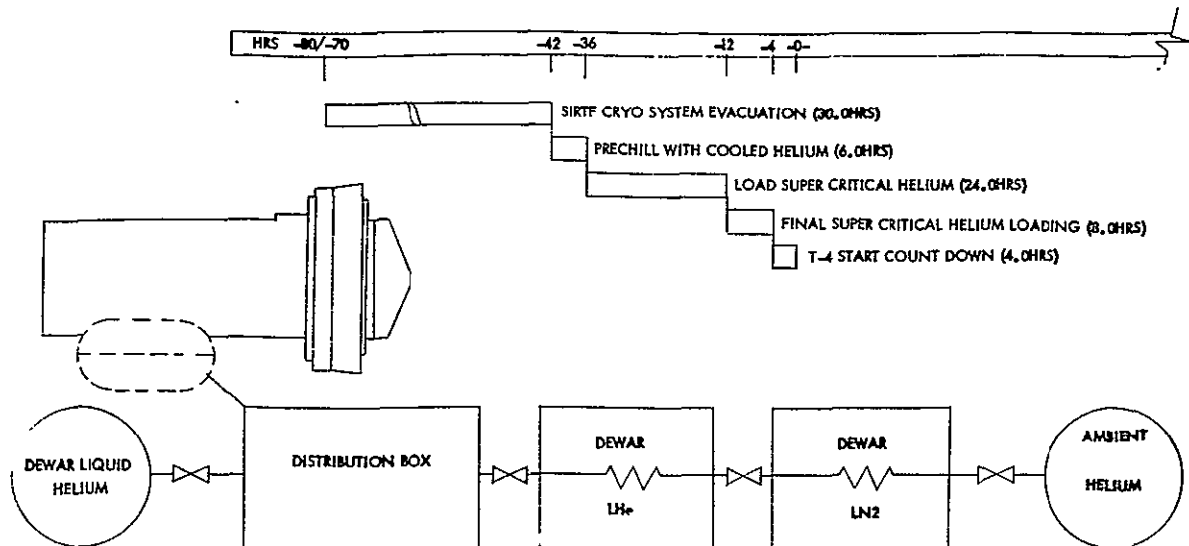


Figure 3-26. Supercritical Helium System Chill, Fill and Top Off

The chardown begins approximately T-42 hours, with ambient helium under high pressure allowed to flow through a liquid nitrogen bath then through a liquid helium bath to a distribution box to the SIRTf cryogenic tank (Figure 3-26). The purpose of this distribution box is to permit chilling and filling of the SIRTf system without disrupting the configuration.

Post-flight deintegration activities are delineated in Figure 3-27. Although these activities are summarized in this figure, the analysis and time estimates reflect the same level of depth as the level IV integration (assembly) previously presented. At completion of the deintegration activities, the pallets are ready for refurbishment/staging for the next payload.

Integrated timelines from the interaction of the staging activity at KSC through post-flight deintegration were developed for each option. Transportation times between sites as well as assembly/checkout activities are included. Current time allocations for KSC-STS operations were used. A mission reference time of seven (7) calendar days was also included. The summary timeline for the distributed options are presented in Figure 3-28. Lead center option summaries are presented in Figure 3-29; KSC options are presented in Figure 3-30. The numbers in each block refer to the functional activities defined in Section 2.0.

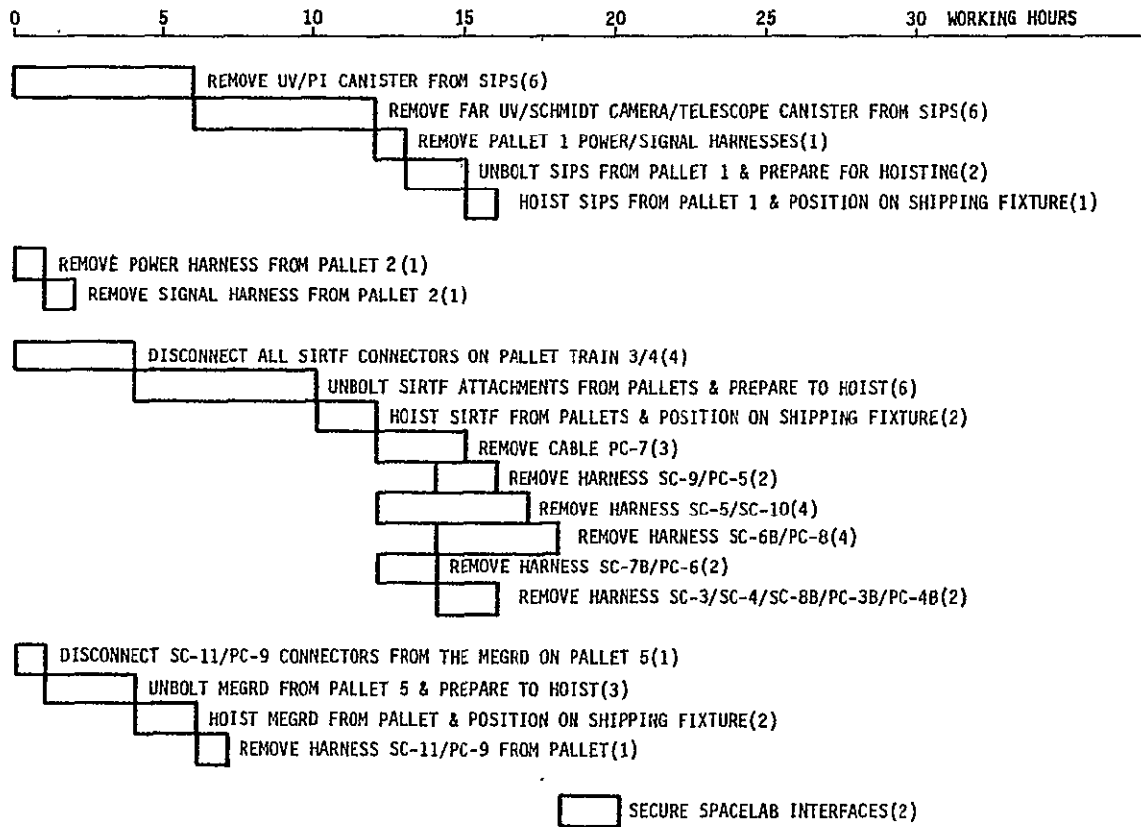
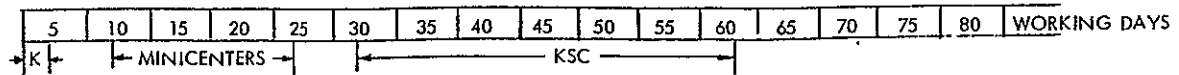
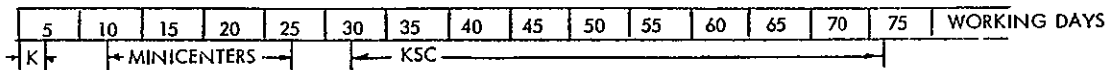
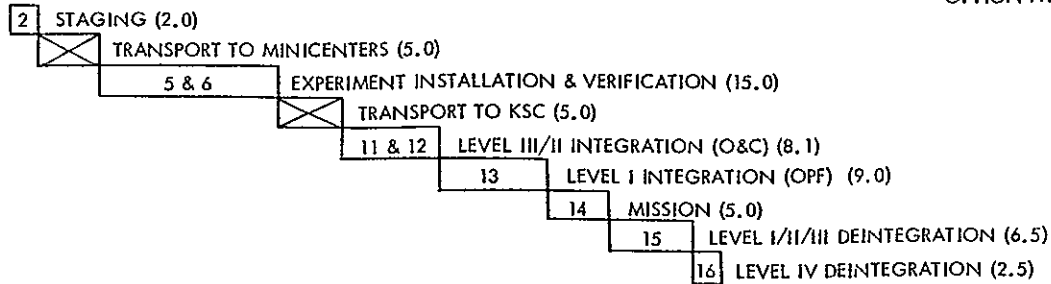


Figure 3-27. Level IV Deintegration - Combined Astronomy



OPTION A1



OPTION A2

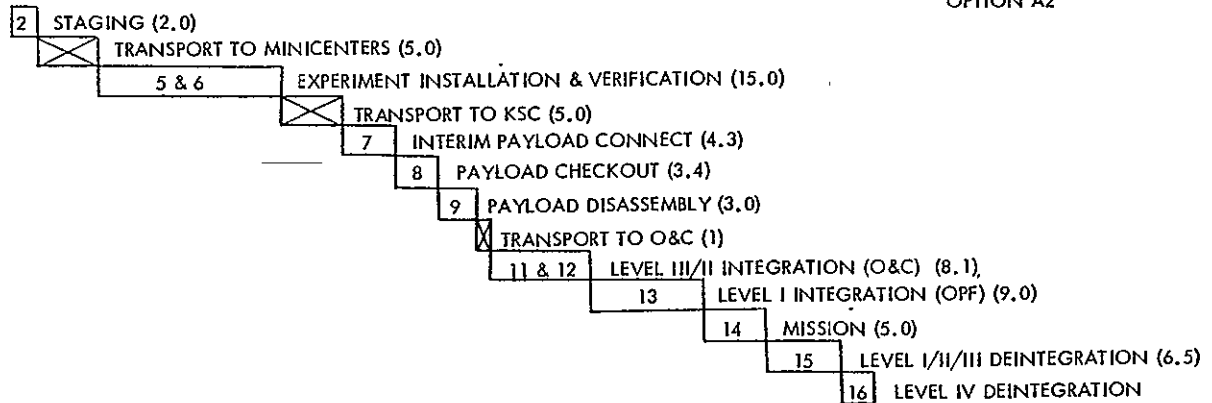


Figure 3-28. Combined Astronomy Ground Processing Flows for Distributed Site Option

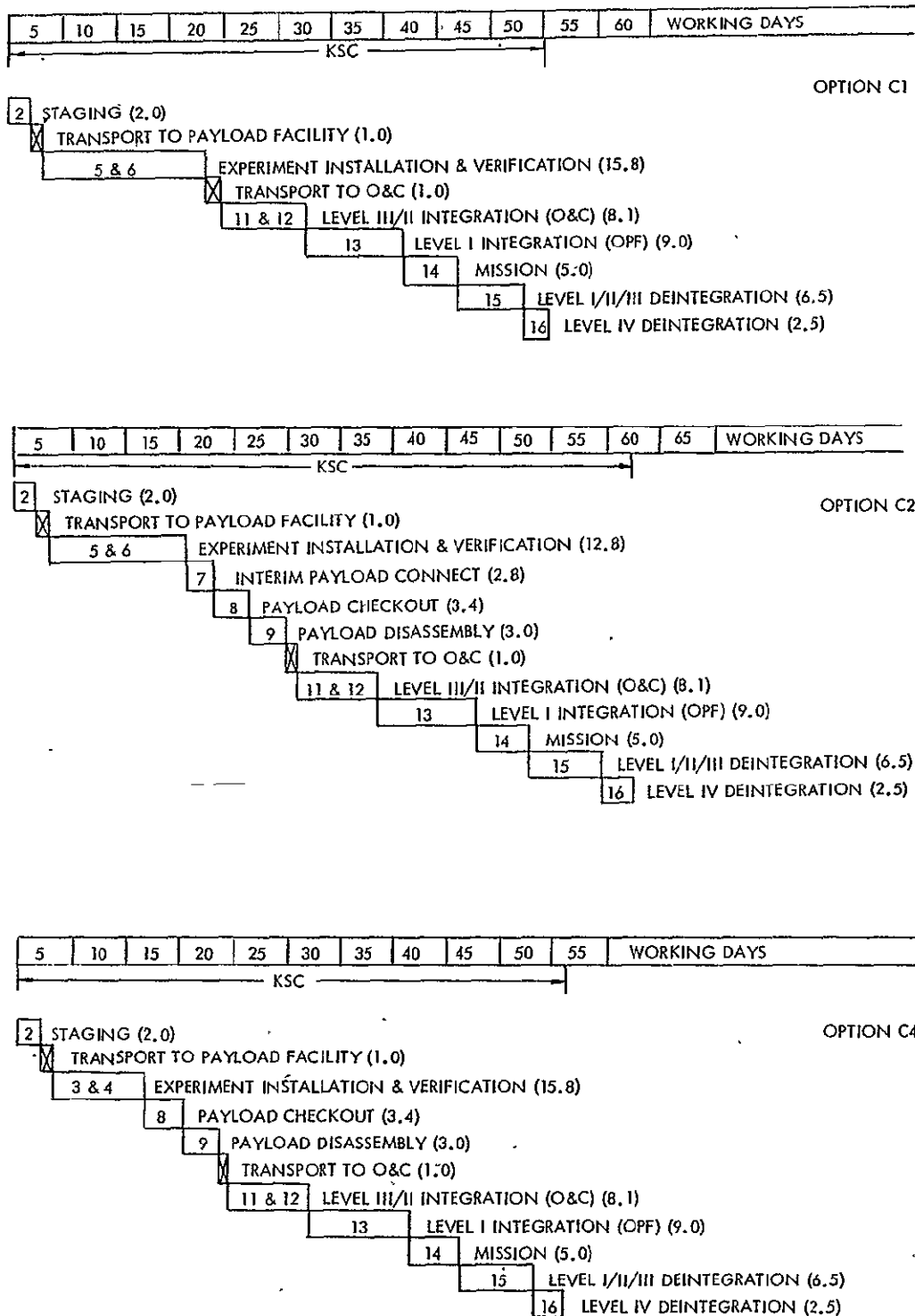


Figure 3-29. Combined Astronomy Ground Processing Flows for KSC Option

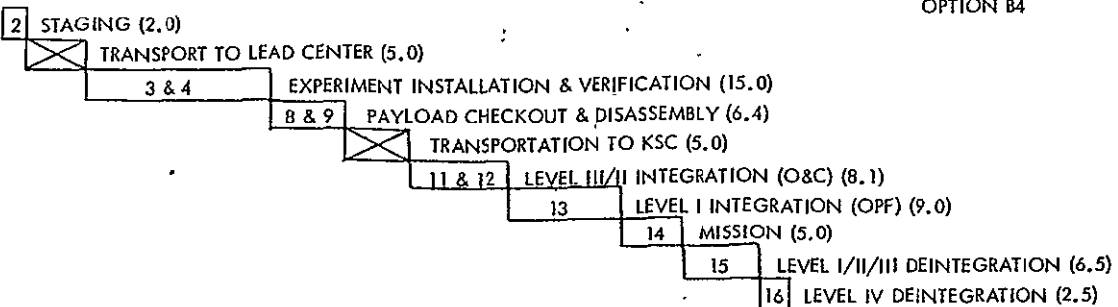
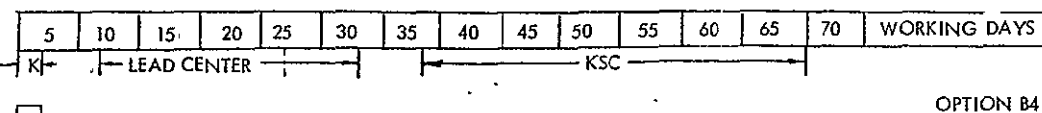
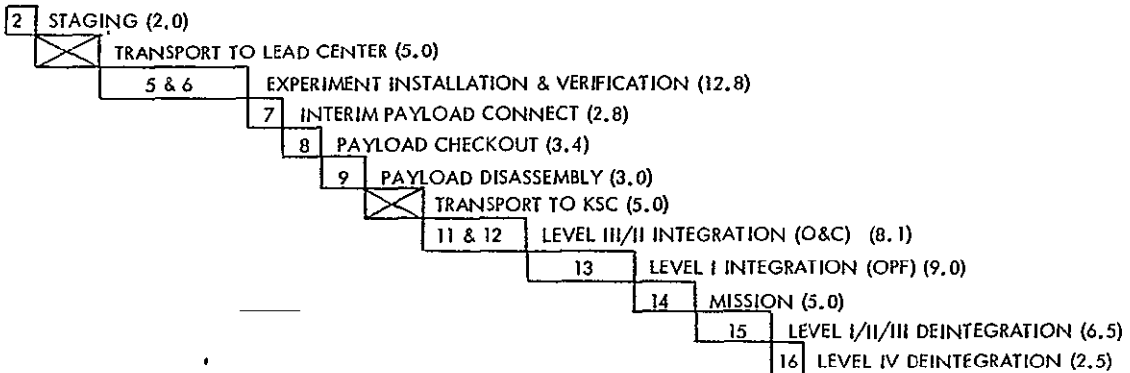
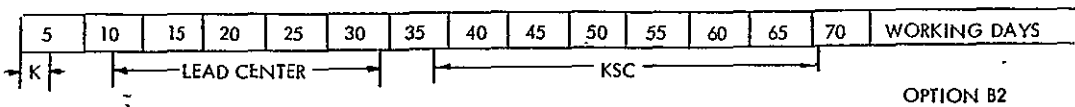
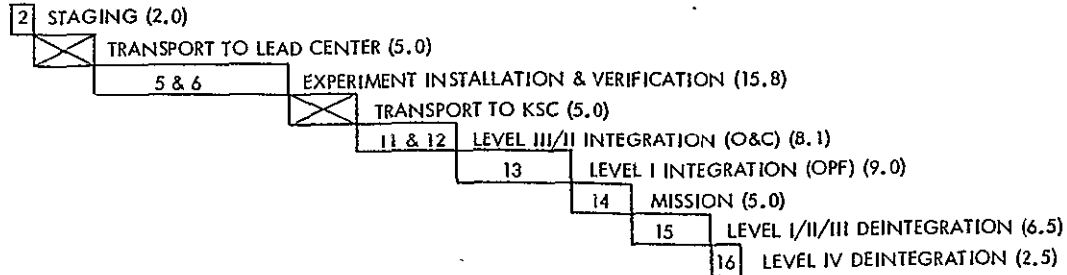
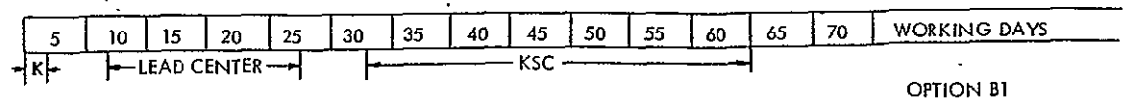


Figure 3-30. Combined Astronomy Ground Processing Flows
for Lead Center Option



LIFE SCIENCES PAYLOAD INSTALLATION & TEST REQUIREMENTS

The Life Sciences payload consists of the Spacelab long module configuration. Experiment equipments are mounted in all of the available racks (10), on core and experiment module floor segments, and in the Orbiter cabin mid-deck and AFD. The habitable module general arrangement is illustrated in Figure 3-31.

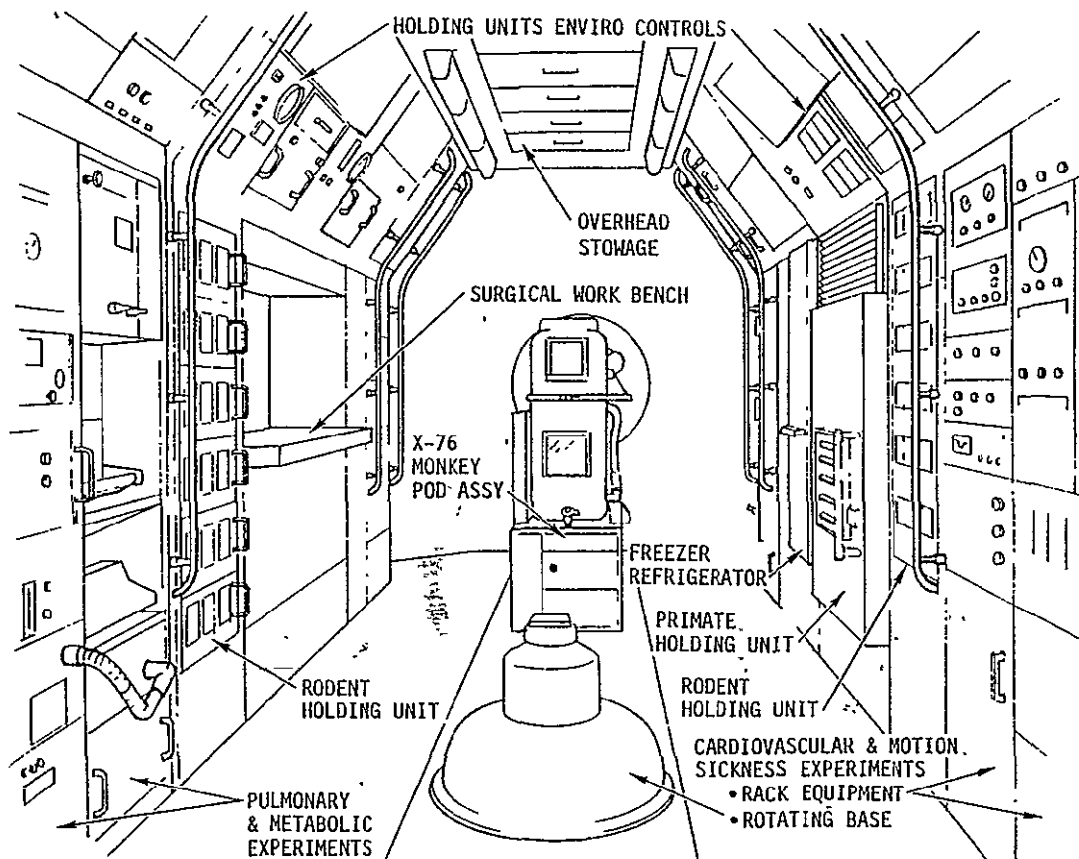


Figure 3-31. General Arrangement for Life Sciences Payload

This view, looking aft in the Spacelab long module, illustrates the key features of the life sciences payload. The majority of equipment items are installed in standard Space-lab racks. These divide almost evenly by volume between standard electronic or electro-mechanical units (amplifier, oscilloscopes, spectrometer, etc.) and special bio-science support elements (specimen holding units, surgical workbench, refrigerator, etc.).

In addition to the rack-mounted equipment, significant floor installations are required. The monkey pod installation provides an environmentally controlled chamber for two primates with automatic feeding and water systems and a controlled lower body negative



pressure. The rotating base assembly supports either a chair or gimbaled platform assembly (normally stowed) and provides for controlled angular rotation or tilt rates.

Considerable volume is required for the stowage of miscellaneous items for the life sciences experiments. This includes smaller instruments (centrifuge, microscope) consumables (specimen food/water) surgical supplies, syringes scissors, etc. Some volume is available in the racks, including consumables. A multitude of smaller items are contained in the over-head stowage.

The experiments included in the module and racks are shown in more detail in Figure 3-32.

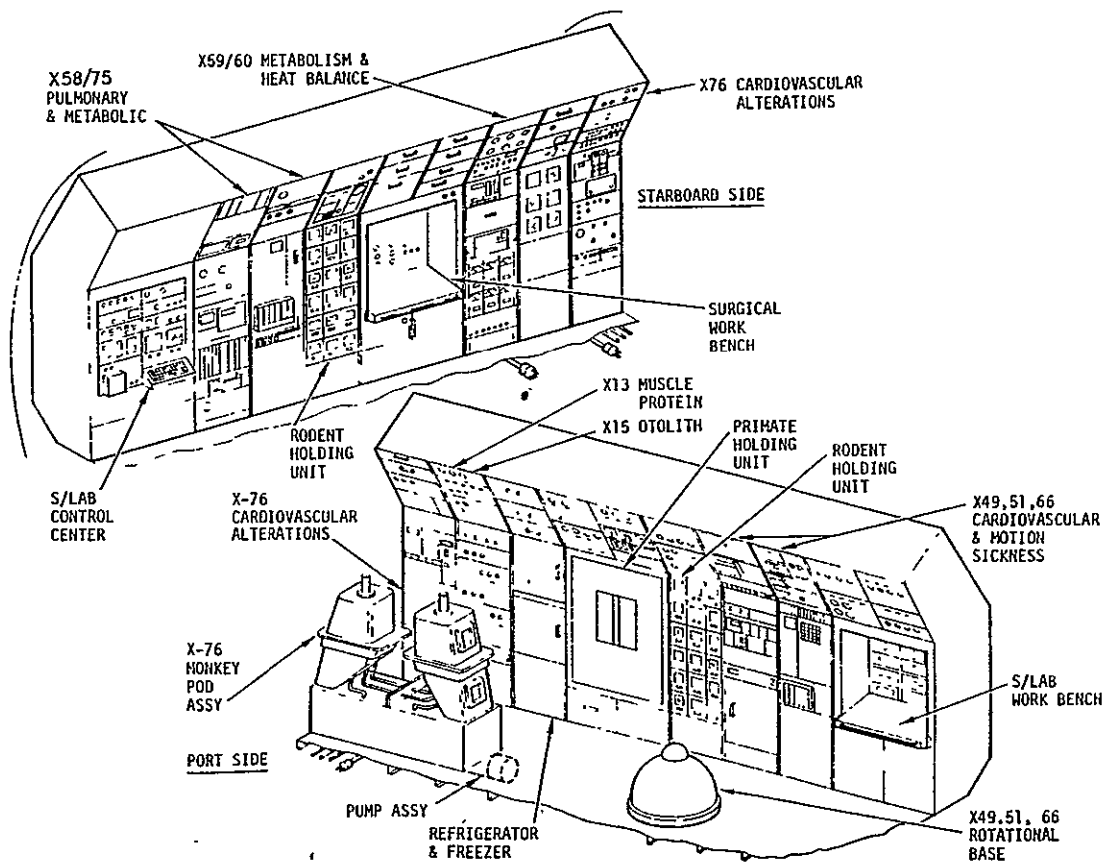


Figure 3-32. Spacelab Module Rack Arrangement For Life Sciences Payload

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Aft of the Spacelab control center on the starboard side is a double rack of equipment including breathing gas analysis equipment--spirometer, pneumotachometer, mass spectrometer--and supporting electronics. The next single and double rack contain common support items, known as CORE (Common Operational Research Equipment). The next double rack contains metabolic rat cages and instrumentation for experiments X59 and 60. The last single rack and the single rack on the aft end of the port side contain pressure control modules and instruments associated with cardiovascular research on the primates in the floor-mounted monkey pod assembly.

Half of the next double rack is occupied by experiment X-13 for the study of muscle protein loss in rats in zero-g. Experiment X-15, also installed in this rack, uses a primate, installed in an oscillating "chair" to measure effects of linear accelerations on the otolith response. The chair is normally stowed.

The rest of this double rack, and the next double and single rack include primarily CORE items. The last experiment double rack contains three experiments associated with the use of the rotating base. Experiments 49 and 51 use a folding litter chair/table for instrumented human subjects. X-49 will study blood pooling (cardiovascular alteration) while 51 will evaluate effects of motion sickness (otology effects of rotation). X-66 uses a gimbaled platform and bull frog specimens to measure otolith output adaptation to zero-g.

The AFD installation is shown in Figure 3-33. The mid-deck installation consists of temporary storage of specimens during launch and entry operations.

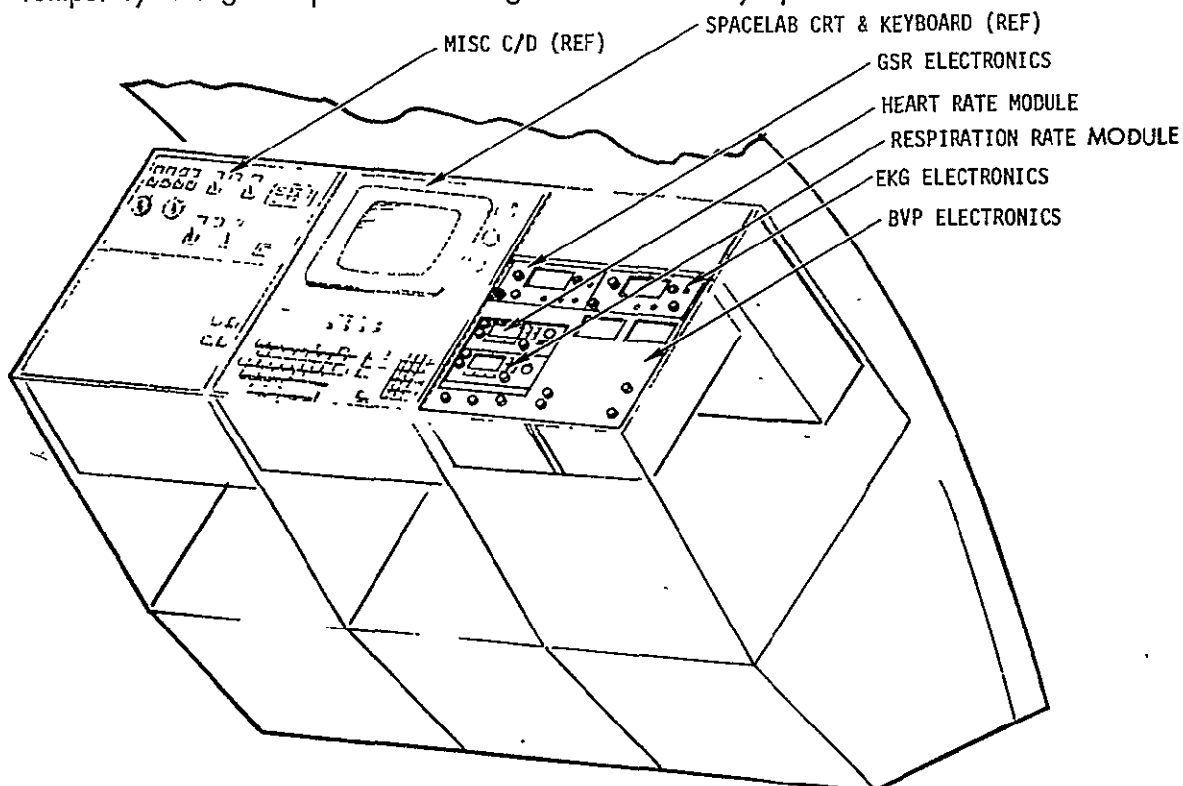


Figure 3-33. Orbiter Aft Flight Deck Arrangement For Life Sciences Payload



Since the experiment equipment installed in the Spacelab module is self-sufficient (with Spacelab support equipment) no aft flight deck controls and displays are required. However, the standard Spacelab CDMS installation will be included at the Payload Station. In addition, one life sciences experiment is designed to be located in the Orbiter.

This experiment, X-5, will measure the ability of individuals to regulate autonomic functions, e.g., biofeedback. Instruments, galvanic skin response through blood volume pulse, provide measurement of success in self regulation for display on the Spacelab CRT.

An added life sciences instrument, a doppler ultrasonic flowmeter (not shown on chart) is installed in the avionics bay for use in measuring temporal arterial flow of an instrumented passenger during ascent and entry.

Transport cages (not shown) for all primates and rodents taken to orbit are designed for attachment to the orbiter mid-deck floor just aft of the forward avionics bay.

Applicable Ground Processing Options

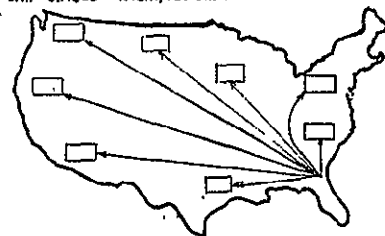
An evaluation of the Life Sciences payload indicated that all but three of the ground processing options defined in Section 2 were applicable. The three exceptions were A-2, B-2, and C-2 because individual experiment/rack integration approaches require a level III assembly activity at KSC (functional block 10). The application of the other nine options was evaluated to form the basis of all ground processing analyses.

Figure 3-34 shows graphically the scenarios for Life Sciences for distributed site, lead center, and KSC. For the distributed site case, the basic philosophy requires shipment of Spacelab racks/floors, RAU's, etc. and supporting GSE to PI's at multiple sites. At the PI's site, experiments are installed/assembled to the Spacelab equipment then transhipped to KSC for final integration including an optional off-line payload level checkout. Only the handling and checkout equipment necessary to perform the level IV integration would be shipped to each distributed site. To these level IV sites are sent the appropriate Spacelab flight and ground support equipment along with the appropriate simulation, test, and checkout equipment. The combined assembly and checkout of individually integrated elements could be accomplished either during Level III/II integration activities at KSC (A-1 option) or in an "off-line" area at KSC (A-3 option) prior to entering into KSC-STS operations.

At a lead center or KSC, Spacelab equipment could optionally be received as individual racks/floors or as an integrated experiment segment, resulting in slightly different flow paths. The lead center approach provides for a total integrated payload checkout and experiment verification at a single site prior to being shipped to KSC. The sharing of GSE end items would be accomplished with appropriate planning/scheduling. If the individual experiment/rack buildup approach is used, combined payload checkout could be performed only during KSC-STS operations (B-1 option) or at the lead center prior to shipment to KSC (B-3 option). If level IV assembly is accomplished at the integrated rack/floor level, the Life Sciences payload could be introduced into KSC-STS operations at the

DISTRIBUTED SITES

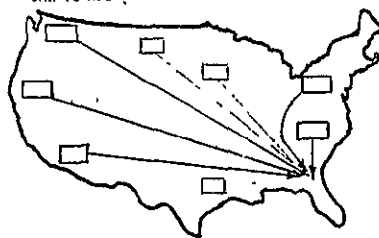
SHIP "STAGED" RACKS/FLOORS & GSE



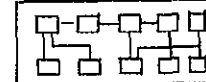
ASSEMBLE
& VERIFY
BY RACK
ASSY



SHIP TO KSC



INTERIM CONNECT & C/O



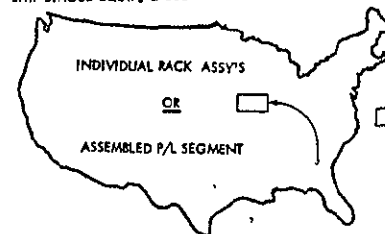
LEVEL III/II ASSY & INTEG, C/O



LEVEL I
&
FLIGHT

LEAD CENTER

SHIP STAGED EQUIP. & GSE



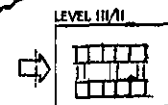
ASSEMBLE
& VERIFY
BY RACK
ASSY



INTERIM CONNECT
& C/O



SHIP TO KSC



LEVEL I
&
FLIGHT

ASSEMBLE
& VERIFY
IN P/L
SEGMENT



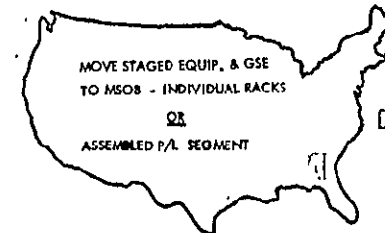
P/L SEGMENT
C/O



KSC

MOVE STAGED EQUIP. & GSE
TO MSCB - INDIVIDUAL RACKS

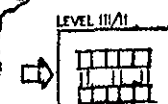
OR
ASSEMBLED P/L SEGMENT



ASSEMBLE
& VERIFY
BY RACK
ASSY



INTERIM CONNECT
& C/O



LEVEL I
&
FLIGHT

ASSEMBLE
& VERIFY
IN P/L
SEGMENT



P/L SEGMENT
C/O



MOVE TO MSCB

Figure 3-34, Life Sciences Ground Processing Scenarios



level III/II main-stand if allowable over-the-road transportation of 16 foot wide loads can be accommodated (B-4 option). If a 10-12 foot width is a transportation restriction, then disassembly of the long module and reassembly in the level III assembly stand is required (B-5 option).

Level IV experiment/Spacelab element integration options at KSC are essentially the same as for the lead center. The one additional feature is the lack of transportation restrictions if a combined payload buildup approach is used. Thus, there is no comparable "C-5" option. However, the C-1, C-3, and C-4 options are viable alternative for ground processing of the Life Sciences payload.

Installation/Integration Constraints

Installation requirements are dependent upon the location and inter-relationship of the experiment equipments. In order to establish the basic tasks, each of the generic ground processing concepts were assessed to establish reasonable groupings of activities.

Distributed Site Options

Conducting level IV integration at twenty-three distributed sites that correspond to the experiment complement (Table 3-7) is not feasible. Theoretically, ten sites corresponding to the ten available racks could be used. However, examination of the experiment and common support-type items, as listed in Table 3-8, shows that some lesser number is more practical. Combining racks 11, 12 and floor segment 4 at one site allows complete integration of all experiment 76 - except one stowage drawer - and adds only two mechanical stowage drawer installations not under the cognizance of this PI. Similarly, racks 5 and 6 were combined at one site since they are identical units, and presumably would be developed under one center/contractor.

Racks 5 and 6, 7 and 8 were combined at sites also. Combining all four racks (5, 6, 7, and 8) at one site was considered because they have similar interfaces (power/fluid), similar installation and verification, and will probably be center/contractor developed common items. However, since different centers could be involved, and in the interest of broadening the distributed site option data, these were retained as individual site operations.

Of the remaining racks, No. 3 would be assigned to one of the three PI's and the experiment equipment from all three experiments would be colocated. Floor segment #2 should be integrated concurrently since major functional interfaces are required. The common support elements listed on the table would also be installed at this site.

Rack 4 would be integrated with colocated experiment 58/76 equipment, with an X-49 transhipped module and the other peripheral equipment listed on the table. The same approach would be followed for rack 9 (X13/15), and rack 10 (X59/60). This analysis resulted in a selection of 8 distributed sites which is a reasonable maximum considering the life sciences experiment complement.



Table 3-7. Life Sciences Payload Experiment Complement

Expt. No.	Title	Study Contract Center
(1) X-3	Rat Collagen Turnover	ARC
(2) X-5	Biofeedback (OAFD Installed)	ARC
(3) X-8	Insulin Resistance	ARC
(4) X-10	Rat Plasma Somatomedin Concentration	Stanford/ARC
(5) X-11	Rat Urinary Excretion of 3-Methyl Histidine	ARC/JSC
(6) X-12	Rat Proteolytic Concentration in Muscle	Univ. of Tex/ARC
(7) X-13	In Vivo Muscle Protein Degeneration	Univ. of Cal/ARC
(8) X-15	Monkey Static-Otolith Activity Change	ARC
(9) X-21	Mice Vestibule-Cerebellum-Vomiting Center and Hypothalamic-Pituitary-Endocrine Axis	ARC
(10) X-23	Rat Brain & Renal Renin-Angiotensin Alteration	Penn St/ARC
(11) X-27	Rat Lymphoid Tissue Histopathological Changes	ARC
(12) X-39	Monkey Resorption Rate Changes	ARC
(13) X-42	Drosophila Development and Aging	ARC
(14) X-49	Human Cardiovascular Alteration	Stanford/ARC
(15) X-51	Motion Sickness Factors	San Jose St/ARC
(16) X-58	Human Pulmonary Function	UCSD Sch. of Med.
(17) X-59	Rat Metabolism and Heat Balance	ARC
(18) X-60	Rats Pyrogenic Fever-Salicylate Interaction	ARC
(19) X-66	Otolith Response Adaption as a Function of CNS Output	JSC
(20) X-68	Erythrokinetics in Man	JSC
(21) X-74	Cellular Immune Response in Man	Baylor Univ.
(22) X-75	Basal and Light Activity Metabolism	JSC
(23) X-76	Monkey Cardiovascular Dynamics	Univ. of Cal/ARC
(24) X-77	Urine Electrolyte Determination	JSC



Table 3-8. Life Sciences Payload Experiment Equipment
Distributed in Spacelab

Rack No.	Major Functional Experiments	Mechanical or Power Only Experiment Equipment	Common Support Elements
3	X-49, 51, 66	—	Refrigerator and Centrifuge
4	X-49, 58, 75	X-77	Radioisotope Monitor
5	—	—	Rodent Holding Unit
6	—	—	Rodent Holding Unit
7	—	X-76	Primate Holding Unit & 60 Hz Inverter
8	—	X-3, 8, 23, 59, 60, and 68	Surgical Workbench
9	X-13, 15	X-42, 75	Refrigerator and Freezer
10	X-59, 60	X-23	—
11	X-76	X-21, 42	—
12	X-76	—	—
<u>Floor Segments:</u>			
2 = FWS, Racks 3, 4, 5 & 6	X-49, 51, 60	—	—
2 = Mid, Racks 7 & 8	—	X-15	—
4 = Aft, Racks 9, 10, 11 & 12	X-76	—	—



The resulting site distribution of equipment is listed by cross-matrix of all experiment designated equipment in Table 3-9. Figure 3-35 illustrates diagrammatically the 8 site equipment assignments, and also identifies inter-rack electrical cable and plumbing requirements. The interconnecting cable/plumbing interfaces would be experiment provided, but would not be accomplished at the distributed sites. Where functional interface verification is required at a distributed site in order to verify a rack installation, either duplicate equipment or a suitable simulator would be employed. For example, the blood pressure measurement system (BPMS) for experiment 49 is installed at Site 2, while experiment 49 is assembled at Site 1. At Site 1, an appropriate input signal to the rack 3 interconnect bracket is required to verify satisfactory installation of the rack 3 cables and modules.

At the conclusion of individual site installation and verification activities, the rack/floor assemblies would be shipped to KSC, where optionally an interim hookup of the individual racks could be accomplished to allow for a combined payload checkout.

Lead Center Options

Performing level IV integration at a lead center could be accomplished either in the same manner as for distributed sites, i.e. individual rack and floor segments, or with a complete assembly of experiment dedicated racks mounted on the floor segments. A primary advantage for the lead center over a distributed site in either case, is the ability to significantly reduce the required GSE. A primary disadvantage is the requirement to provide travel funds for experiments personnel. The discrimination between individual racks vs. an assembled partial module occurs in serial/peak processing activities as discussed in later analyses. The assembled option also allows installation of most of the inter-rack cables and plumbing which would otherwise be deferred to KSC.

KSC Options

These options have the same basic scenario as the lead center, however, transportation is only required on-site at KSC from one facility to another.

Ground Processing Equipment Requirements

Level IV activities are initiated upon receipt of all of the equipment necessary to accomplish installation and verification procedures. This premise was applicable for distributed site or central site activities. Basic equipment groups include Experiment equipment, Spacelab flight hardware, Special Test Equipment (experimenter provided) and Common Ground Support Equipment (Spacelab provided).

Experiment Equipment

The list of Life Science experiment equipment (by end item) was given in Table 3-9. The level IV experiment equipment totals 158 items that will be installed in racks and in non-rack locations such as on the floor segments, in the Orbiter aft flight deck, and in the Orbiter mid deck. Table 3-10 summarizes this equipment, and identifies differences in



Table 3-9. Distributed (Mini) Centers Experiment Installation

SITE # 1

MATRIX, LIFE SCIENCES EQUIPMENT - PORT RACK INSTALLATION

RACK		NAME	END ITEM	O T R	C O R E	EXPERIMENT NO.																							
S /L	L /S					3	5	8	10	11	12	13	15	21	23	27	39	42	49	51	58	59	60	66	68	74	75	76	77
3	7	TV MONITOR	49-8													X													
		OSCILLOGRAPHIC RECORDER	49-2													X													
		TIME CODE GENERATOR	66-1																		X								
		AUDIO MONITOR	66-2																		X								
		MICRODRIVE	66-3																		X								
		POWER MODULE & STRIP	66-4																		X								
		OSCILLOSCOPE	66-5																		X								
		REFRIGERATED CENTRIF.	8-3,1		X		X	X	X							X							X	X					
		REFRIGERATOR	8-4		X		X	X	X			X	X	X	X	X					X	X	X			X			
	8	CARDIOTACH, FLOW MTR. PR. VIBR.	49-3													X													
		ECHOCARDIOGRAM & TV CAMERA	49-1													X													
		ISOLATION AMPLIFIER	58-10													X					X								
		ROTATING BASE CONTROL CONSOLE	49-5													X	X				X								
		OSC. RECORD & CHAIR CTRL	49-5													X	X				X								
		CENTRIF. REFRIG. & GAS SHUT.	8-3,2		X		X	X								X							X	X					
		(SPACELAB - EPSP & RAU)	-																										

SITE # 2

MATRIX, LIFE SCIENCES EQUIPMENT - STARBOARD RACKS INSTALLATION

RACK 5/L 1/5	NAME	END ITEM	O T R	C O R E	EXPERIMENT																							
					3	5	8	10	11	12	13	15	21	23	27	39	42	49	51	58	59	60	66	68	74	75	76	77
4 ↑ 13	CPU DATA REDUCT. & PRINTER. (GAS BOTTLE ASSY) - BEHIND RACK	75-3	1																X							X		
	CPU POWER SUPPLY	58-6	1																X							X		
	FLOW-VOLUME ELECTRONICS	75-4	1																X							X		
		58-3																	X							X		
	SPIROMETER	75-5	1																X							X		
	BLOOD PRESS. MEAS. SYST. (BPMS)	49-7	1															X								X		
	RADIO ISOTOPE SURV. MET. LIQ. SCIN.	68-4		X																				X		X		
	FLOW CONTROL UNIT MIXING CHAMBER	75-1 75-2	8																							X		X
	RADIO ISOTOPE AIR MONITOR INTERFACE PANEL (SPACELAB ICRS)	76-28 58-4	1	X	X						X									X				X		X		
		-																										
	MASS SPECTROMETER	58-1																	X							X		
	PNEUMOTACHOMETER	58-2																	X									
	STRIP CHART RECORDER	58-5																	X									
	URINE ELECTROLITE ANALYZER	77-1																		X								
	(SPACELAB EPSP & RAU)	-																									X	

SITE # 3

MATRIX, LIFE SCIENCES EQUIPMENT - PORT RACK INSTALLATION

RACK 5 L 5	NAME	END ITEM	O T R	C O R E	EXPERIMENT NO.																							
					3	5	8	10	11	12	13	15	21	22	27	39	42	49	51	58	59	60	66	68	74	75	76	77
5 ↓ 6	RODENT WATER SUPPLY RODENT H.F. CTRLS/DISPLAY RODENT HOLDING FACILITY (SPACELAB - EPSP)	10-3 10-2 10-1 -	14/16					X			X			X					X	X		X						
6 ↓ 15	RODENT WATER SUPPLY RODENT HF CONT/DISPLAY RODENT HOLDING FACILITY (SPACELAB-EPSP)	3-5 3-7 3-6 -			X X 6			X X 6	X X 20			X X 25	X X 24															



Table 3-9. Distributed (Mini) Centers Experiment Installation (Cont'd)

SITE # 4

MATRIX, LIFE SCIENCES EQUIPMENT - PORT RACK INSTALLATION

RACK		NAME	END ITEM	O T R	C O R E	EXPERIMENT NO.																							
S /	L /					3	5	8	10	11	12	13	15	21	23	27	39	42	49	51	58	59	60	66	68	74	75	76	77
7 ↑	4 ↓ 4/5	BSHF WATER SUPPLY STOWAGE - MONKEY PODS PRIMATE HOLDING UNIT	15-11 76-26 15-7	14/16						X				X												X			
	5 ↑	BLANK A-C INVERTER - 60 HZ PRIMATE H.F. CTRLS/DISPL. (SPACELAB - ICRS - - EPSP)	- 15-12 15-8 -			X	X	X		X	X	X		X		X	X	X	X	X	X	X		X	X				

RACK		NAME	END ITEM	O T R	C O R E	EXPERIMENT																							
S/L	L/S					3	5	8	10	11	12	13	15	21	23	27	39	42	49	51	58	59	60	66	68	74	75	76	77
8	16	INSTRUMENTS/SUPPLIES	3-3			X																							
		STOWAGE BLOOD ACQ. KITS	8-1				X	X														X	X						
		RADIO ISOTOPE SAMPLES	68-1																										
	16/17	SURGICAL WORKBENCH	68-3			X	X	X	X	X	X	X	X	X	X	X	X					X	X			X			
		STOWAGE ANGIO. & BALANCE PAN	23-1																										
	17	STOWAGE - RADIOACTIVE WASTE	3-2			X					X			X	X														
		STOWAGE - WASTE	59-13																										
		(SPACELAB-EPSP)																											

SITE # 6

MATRIX, LIFE SCIENCES EQUIPMENT - PORT RACK INSTALLATION

RACK S/L	NAME	END ITEM	O T R	C O R E	EXPERIMENT NO.																							
					3	5	8	10	11	12	13	15	21	23	27	39	42	49	51	58	59	60	66	68	74	75	76	77
9 ↑ -2 ↑	ISOLATION AMPLIFIER SIGNAL CONDITIONER STRAIN GAUGE PWR SUPPLY SCOPE SELECTOR A.C. POWER FILTER	13-6 15-3 15-2 15-4 15-6									X	X																
	OSCILLOSCOPE IR ANALYZER/OUTPUT MONITOR " /GAS FLOW CALIB. RESPIRATORY CAGES VIBRATION REED ELECTROMETER	15-5 13-2 13-3 13-1 13-4 13-5									X	X																
3 ↑	STOWAGE DIGITAL TAPE RECORDER DROSOPHILA CAMERA (STOW)	- 75-6 42-1																X									X	
	REFRIGERATOR - RAT FOOD SLIDE TABLE FREEZER (SPACELAB - EPSP & RAU)	3-4 - 8-5 -			X	X	X	X	X	X	X	X	X	X	X	X				X	X			X				
			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X						X	X			X	



Table 3-9. Distributed (Mini) Centers Experiment Installation (Cont'd)

SITE # 7		MATRIX, LIFE SCIENCES EQUIPMENT - STARBOARD RACKS INSTALLATION																											
RACK S/L	L/S	NAME	END ITEM	O T R	C O R E	EXPERIMENT																							
						3	5	8	10	11	12	13	15	21	23	27	39	42	49	51	58	59	60	66	68	74	75	76	77
10	18	METABOLIC CAGE AIR FILTERS	59-11																X										
		METABOLIC RCVR/PYROGEN TUNING	59-4																X	X									
		OSCILLOSCOPE SELECTOR	59-10																X	X									
		DATA LOGGER	59-1																X	X									
		TAPE RECORDER-ANALOG	59-2																X	X									
		TORSION BALANCE (SLIDE)	23-2																X										
		METABOLISM FLOW METERS	59-3																X	X									
		CAGE AIR FLOW CONTROL	59-6																X	X									
19	19	POWER SUPPLY	59-8															X	X										
		RAT WATER SUPPLY/ACCESS	59-9																X										
		OSCILLOSCOPE	59-14																X										
		AIR (GAS) ANALYZER/M. S. SEQ.	59-5																X										
		(SPACELAB - ICRS)	-																X										
		METABOLIC CAGES	59-7																X										
		DPIERITE COLUMNS & CAGE CTRL.	59-12																X										
		(SPACELAB-EPSP)	-																X										

SITE # 8		MATRIX, LIFE SCIENCES EQUIPMENT - STARBOARD RACKS INSTALLATION																											
RACK		NAME	END ITEM	O T R	C O R E	EXPERIMENT																							
S/L	L/S					3	5	8	10	11	12	13	15	21	23	27	39	42	49	51	58	59	60	66	68	74	75	76	77
11	1	STOWAGE - PERFUSION PUMP	21-1								X																		
		DROSOPHILA STOWAGE	42-2														X												
		OSCILLOSCOPE (POD) SELECTOR	76-7																							X			
		DEMODULATOR PATCH PANEL	76-6																						X				
		TELEMETRY TUNE/RECEIVER	76-4																						X				
		DEMODULATOR	76-5																						X				
		UPPER POD A FLOW CONTROL	76-30																						X				
		TELEMETRY TUNE/RECEIVER	76-16																						X				
		DEMODULATOR	76-17																						X				
		UPPER POD B FLOW CONTROL	76-11																						X				
		(SPACELAB - EPSP)	-																										
12	20	CTRL CALIBR. GASES	76-25																							X			
		M. S. CALIBRATION CONTROL	76-18																							X			
		SIGNAL CONDITIONER	76-2																							X			
		BUFFER AMPLIFIER	76-8																							X			
		BUFFER AMPLIFIER	76-19																						X				
		HEART RATE/DIFFER. PRESSURE	76-9																							X			
		MASS SPECTROM. & SAMPLE VALVES	76-20																X							X			
		MASS SPECTROMETER CONTROLS	76-21																X							X			
		LBNP CONTROLS	76-10																							X			
		BARATRON-AMP. PRESSURE	76-23																							X			
		PART. PRESS. RATIO COMPUTER	76-24																						X				
		(SPACELAB-EPSP & RAL)	-																										
RACK		NAME	END ITEM	O T R	C O R E	EXPERIMENT																							
S/L	L/S					3	5	8	10	11	12	13	15	21	23	27	39	42	49	51	58	59	60	66	68	74	75	76	77



Table 3-9. Distributed (Mini) Centers Experiment Installation (Cont'd)

MATRIX, LIFE SCIENCES EQUIPMENT - NON RACK-INSTALLED																														
INTEGR LEVEL	LEVEL IV SITE	LOCATION	NAME	END ITEM NO.	O R NO.	C O O P E R A T I O N	EXPERIMENT NO.																							
							3	5	8	10	11	12	13	15	21	23	27	39	42	49	51	58	59	60	66	68	74	75	76	77
IV/III	1	END	FROG GIMBAL PLATFORM (STOW)	65-8																										
IV	8	aisle	MONKEY PODS (A&B)	76-122																										
IV	-	"	X-15 FLOOR MOUNT	15-9										X															X	
IV	1	"	ROTATING BASE ASSEMBLY	19-4																										
I	-	QMD	RODENT TRANSPORTERS	3-1	18		X		X	X	X	X	X	X	X	X	X	X	X											
III	-	"	PRIMATE TRANSPORTERS	15-10	18										X			X											X	
III	-	OVHD	HEMATOCRIT CENTRIFUGE (STOW)	2-2					X																					
I	-	REFRIG.	FROG-HOLDING FACILITY	66-7																										
III	-	aisle	MICROSCOPE-ARM MOUNT (STOW)	60-9																										
III	-	"	MONKEY OSCILL. PLAT. & ACCEL. (STOW)	15-1										X																
II	-	QAFD	RESPIRATION RATE MODULE	5-1					X																					
II	-	"	GALVANIC SKIN RESPONSE MOD.	5-2					X																					
II	-	"	ELECTROMYOGRAPH MODULE	5-3					X																					
II	-	"	BLOOD VOLUME PULSE ELEX.	5-4					X																					
II	-	"	HEART RATE MODULE	5-5					X																					
II	-	"	STOWAGE DRAWER	5-6					X																					
I	-	ORB, MID-DK	ULTRASONIC (DOPPLER) FLOW METER	49-6																X										
III	-	STOW	MICROSCOPE	68-2																							X			
III	-	"	MATING CAGE	60-5																							X			
IV	8	POD ASSY	TEMPERATURE MULTIPLEXER	76-13																									X	
IV	8	"	BASE, POD A	76-15																									X	
IV	8	"	BASE, POD B	70-12																									X	
IV	8	"	PODS INTERFACE PANEL	76-3																									X	
IV	8	"	MONKEY POD FOOD DRAWER	76-27																									X	
IV	8	"	H ₂ O COLLECTION/FILTER ASSY	70-29																									X	
IV	8	"	FEEDER/WATER SUPL. SIGN. CONDIT.	70-31																									X	
IV	8	"	CAMERA DRAWER, MONKEY POD	76-32																									X	
IV	8	"	WATER STORAGE DRAWER	76-14																									X	
III	-	STOW	HAND HELD VOICE RECORDER,	51-1																										
III	-	STOW	ELECTRODES & AMPLIFIER-STOWED	60-6																	X									
IV/III	1	STOW	TILT TABLE/LITTER CHAIR	51-2																X	X									
IV/III	1	STOW	TILT ANGLE TRANSDUCER	49-9																X	X									
IV	8	BELOW FLOOR	PUMP ASSEMBLY	70-33																									X	
-	-	"	(SPACELAB - EPDS & GAG)	-																										

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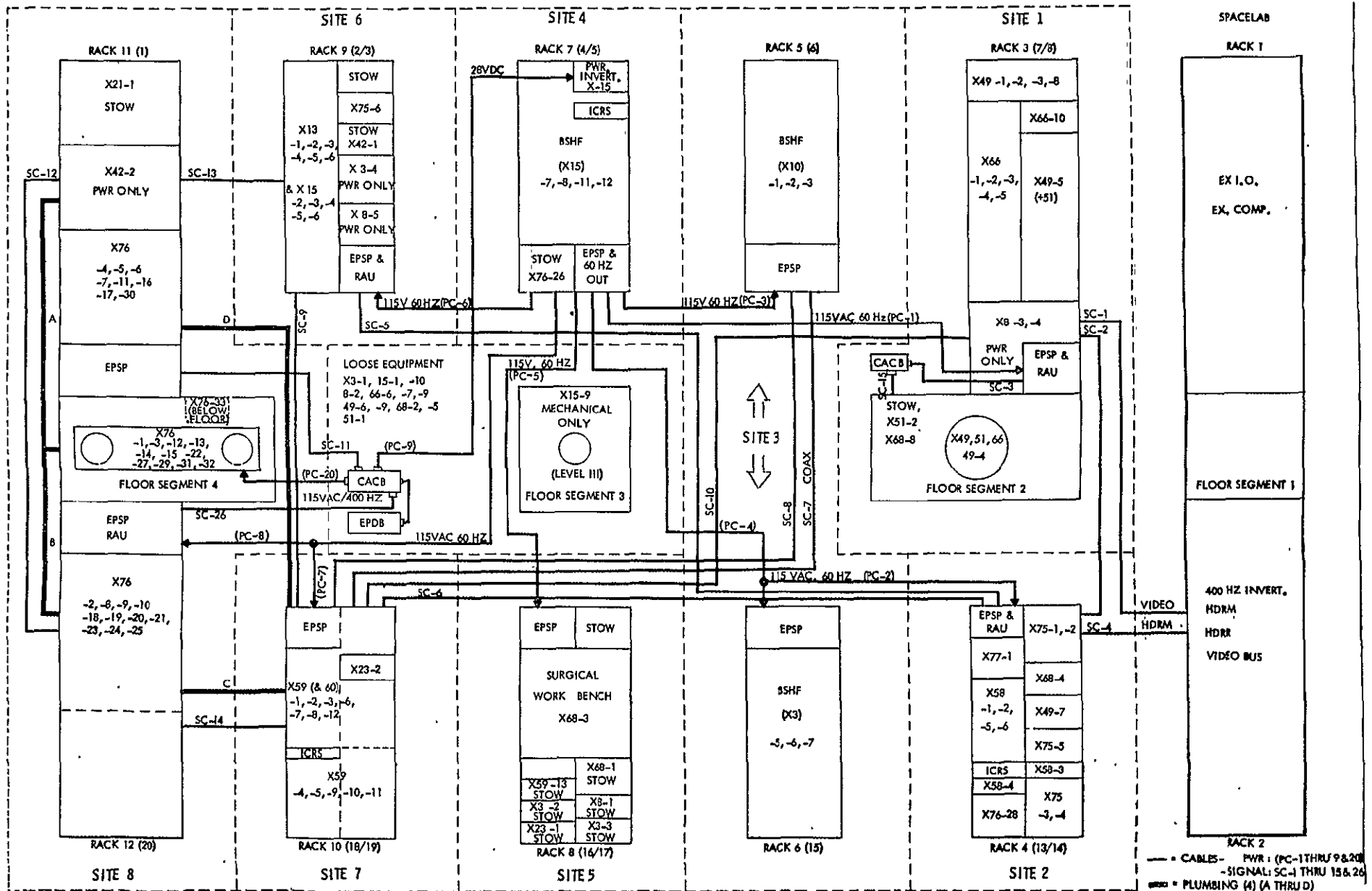


Figure 3-35. Rack/Floor Site Distribution and Inter-Rack Connections

3-72



assembly level among concepts. All 97 end items and 20 rack cable sets can be installed at distributed sites, as well as at a lead center. Three of the four floor installations could be completed at distributed sites. The monkey chair base plate installation was deferred to Level III in this case. Eleven of 13 plumbing sets could be installed. Thus, deferring 2 sets for Level III with the distributed site concept or a non-integrated option at a centralized site. Of the total of 26 inter-rack cable harnesses, only six can be installed in distributed site or non-integrated centralized site lead center options. Even with a pre-assembled payload, however, 2 of the twenty-six must be deferred to Level III. Bio-specimens in their transporter cages will be installed into the Orbiter at Level I, although previous inspection and preparation could be required at the sites noted.

Table 3-10. Life Sciences Equipment Requirements Summary

DWG.	ITEM DESIGNATION	LEAD CENTER REQMTS.	DISTRIBUTED (MINI) CENTERS							
			SITE #1	SITE #2	SITE #3	SITE #4	SITE #5	SITE #6	SITE #7	SITE #8
	EXPERIMENT END ITEM/EQUIPMENT	99	15	14	5	5	7	17	14	21
	RACK INSTALLED EXPERIMENT END ITEMS	20	2	2	4	2	2	2	2	4
	INTER-RACK CABLE SETS(26 TOTAL, 23 LEVEL III ONLY)	24	2							4
	MONKEY POD FLOOR INSTALLATION	1								1
	MONKEY CHAIR FLOOR INSTALLATION	1								
	ROTATING BASE FLOOR INSTALLATION	1	1							
	PLUMBING INSTALLATIONS	13		1	2	1	1	1	1	4
	BELOW FLOOR PUMP ASSEMBLY	1								1
	ORBITER INSTALLATION (OAFD, OMD) (LEVEL II)	(2)								
	SPECIMEN TRANSPORTERS (LEVEL I)	(10)			(6)	(1)			(1)	(2)

Spacelab Flight Hardware

Spacelab-unique equipment consists of all those items of Spacelab equipment that are normally provided by the Spacelab program. A list of the required Spacelab equipment is shown in Table 3-11. The major equipment items required for Life Sciences Level IV experiment installation and interface verification are the single and double racks, EPSP's, EPDB, RAU's, CACB, ICRS's, triple floor segments and a double floor segment.

Table 3-11. Life Sciences Payload Spacelab Interfacing Equipment

DWG.	ITEM DESIGNATION	LEAD CENTER REQMTS.	DISTRIBUTED (MINI) CENTERS							
			SITE #1	SITE #2	SITE #3	SITE #4	SITE #5	SITE #6	SITE #7	SITE #8
	RACKS, LONG MODULE SPACELAB, DOUBLE	6	1	1		1	1	1	1	
	RACKS, LONG MODULE SPACELAB, SINGLE	4			2					2
	EXPERIMENT POWER SWITCH PANELS (EPSP)	10	1	1	2	1	1	1	1	2
	EXPERIMENT POWER DISTRIB. BOX (EPDB)	1								1
	REMOTE ACCESS UNITS (RAU'S)	4	1	1				1		1
	CACB (FLOOR)	2	1							1
	INTERCOMM REMOTE STA. (ICRS PANELS)	3		1		1			1	
	FLOOR SEGMENT, TRIPLE	2	1							1
	FLOOR SEGMENT, DOUBLE	1								



Ground Support Equipment

The Ground Support Equipment (GSE) listed in Table 3-12 is common Spacelab provided support equipment that is used for Level IV experiment integration at each of the eight distributed (mini) sites or a lead center/KSC. These GSE items will be used for installation and verification activities. Additional equipment items are used for transport and handling of Spacelab Flight Hardware. It can be noted that a lead center concept requires considerably fewer items than the total of all distributed sites.

Table 3-12. Life Sciences Payload GSE Requirements

DWG.	ITEM DESIGNATION	LEAD CENTER REQMTS.	DISTRIBUTED (MINI) CENTERS							
			SITE #1	SITE #2	SITE #3	SITE #4	SITE #5	SITE #6	SITE #7	SITE #8
	GROUND SUPPORT EQUIPMENT									
612002A	TRANSPORT DOLLY, RACK & FLOOR	1	1	1	1	1	1	1	1	1
612006A	VERTICAL SLING KIT, RACK & FLOOR	1	1	1	1	1	1	1	1	1
612047A	RACK & FLOOR SHIPPING COVER	1	1							1
612048A	RACK & FLOOR TRANSPORT PLATFORM	1	1							1
612049A	RACK & FLOOR SUPPORT BRACES KIT	1	1							1
612050A	DOUBLE RACK HANDLING C/O & TRANSPORT KIT			1		1	1	1	1	
612065A	SINGLE RACK HANDLING C/O & TRANSPORT KIT				2					
612068A	DESICCANT CANISTER, MEDIUM, DOUBLE RACK	6	1	1		1	1	1	1	2
612069A	DESICCANT CANISTER, SMALL, SINGLE RACK	4			2					
612071A	ACTIVE ENVIRONMENTAL CONTROL CART	1								
612106A	ROAD TIEDOWN KIT, U.S.	1	1	1	1	1	1	1	1	1
614XXX	TRANSPORTATION INSTRUMENTATION	1	1	1	1	1	1	1	1	1
612XXX	OPERATORS CHECKOUT CONSOLE	1	1	1	1	1	1	1	1	1
613038	CONTINUITY TESTER, ELECTRICAL	1	1	1	1	1	1	1	1	1
613039	GROUNDING/BONDING TESTER	1	1	1	1	1	1	1	1	1
612XXX	VACUUM PUMPING UNIT	1		1			1			1
612XXX	RACK COOLING UNIT (SUPPORT C/O)	1	1	1	1	1	1	1	1	1
612XXX	GAS, BOTTLES, SUPPLY UNIT	1		1				1	1	
614XXX	GN ₂ SERVICE SET	1				1			1	
612114A	CLEANING KIT	1	1	1	1	1	1	1	1	1

Special Test Equipment

In addition to the Spacelab oriented GSE, several items of experiment unique test equipment were identified (Table 3-13). These items would be provided by the experimenters and used during verification tests. This special test equipment is solely for interface verification purposes; it is not intended for use in conducting performance/specification tests.

Table 3-13. Life Sciences Payload Special Test Equipment

DWG.	ITEM DESIGNATION	LEAD CENTER REQMTS.	DISTRIBUTED (MINI) CENTERS							
			SITE #1	SITE #2	SITE #3	SITE #4	SITE #5	SITE #6	SITE #7	SITE #8
---	HUMAN PHYSIOLOGICAL SIMULATOR (PI FURN.)	1	1							
---	FROG SIMULATOR (PI FURN.)	1	1							
---	RAT SIMULATOR (PI FURN.)	1			1					
---	OCULOGRAPHIC SIMULATOR (PI FURN.)	1						1		
---	MASS SPEC ANALOG DATA SIMULATOR (PI FURN.)	1							1	
---	RAT TEMPERATURE OUTPUT SIMULATOR (PI FURN.)	1							1	
---	MONKEY PHYSIOLOGICAL SIMULATOR (PI FURN.)	1								1



Installation and Test Procedures

Level IV installation and test activities are similar activities, whether performed at distributed sites, lead center, or KSC or whether the integration is accomplished by individual rack or at the payload level of assembly. The major difference occurs in that experiment verifications would be performed after installation on all racks/floors in the case of payload level buildup rather than after each individual rack is assembled.

Assembly Procedures

The assembly procedure for the Life Science experiments consists of mounting the experiment end item modules into the standard 19-inch Spacelab racks and on the floor segments. The assembly procedures are based on standard Spacelab installation methods which will provide high operational reliability and safety. The assembly procedures, including inspection, will assure:

- (1) Smooth and even contact between assembled components, both electrical and mechanical
- (2) Application of specific torques
- (3) Assurance of non-interference between end items
- (4) Alignments as required.

Assembly will be conducted in approved and designated area only and by properly trained personnel.

The rack frames arrive at the Level IV experiment installation site with the rack sub-systems pre-mounted. This includes the RAU's, power systems, and EPSP. The racks are either positioned on the rack frame stands for Level IV activities, or arrive in an assembled payloads configuration. The Life Science experiment modules are then mounted into the rack frames (and floor segment) and the appropriate electrical and fluid interfaces made. This includes electrical harnesses, command and data cables and fluid line connections.

This same installation procedure is used at the distributed sites, lead center, or KSC. The basic procedure remains unchanged whether an individual experiment or a complete payload is processed through a Level IV installation activity. All necessary installation items will be available at the Level IV site prior to beginning the installation sequence.

A series of flow diagrams was prepared to define the basic sequence of operations for the assembly process. Figures 3-36 through 3-43 define these sequences for Sites 1 through 8, and would be the same for lead center concepts with non-assembled rack frames. Figure 3-44 illustrates the flow diagram approach for an assembled payload.



SITE #1, RACKS # 3a, 3b, & FLOOR SEGMENT

GROUND ASSEMBLY FLOW, SITE 1

FLOOR SEGMENT EQUIPMENT

FOLDOUT FRAME 1

FOLDOUT FRAME 2

RACK # 3a EQUIPMENT

SEQUENCE OF
INSTALLATION



- | | |
|---|-----|
| TV MONITOR
EI #49-1 | 10. |
| OSCILLOSCOPE
RECORDER
EI #49-2 | 9. |
| BLANK | |
| TIME CODE GENERATOR
EI #66-1 | 8. |
| AUDIO MONITOR
EI #66-2 | 7. |
| MICRODRIVE
EI #66-3 | 6. |
| STRIP
POWER MODULE
EI #66-4 | 5. |
| OSCILLOSCOPE
EI #66-5 | 4. |
| REFRIGERATED
CENTRIFUGE
(SLIDE OUT)
EI #8-3a | 2. |
| REFRIGERATOR
EI #8-4 | 1. |
| BLANK | |

STEP 5: EXPERIMENT CHECKOUT AND INTERFACE
VERIFICATION
After GSE connection the experiments will under-
go checkout and interface verification. The per-
ipheral equipment and checkout console will operate
and control the experiments, perform fault isolation
and trouble shooting, data record and display, and
simulate experiment functions.

PREPARE FOR TRANSPORT: INSTALL BACK
AND FLOOR SHIPPING COVER
(DWG #612047A)

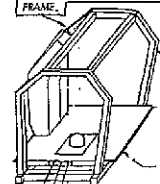
STEP 6: PREPARE FOR TRANSPORT

After completion of interface verification the racks
and floor segment will be prepared for shipment. The
rack and floor transport platform and the rack and floor
support braces kit will be loaded and covered with the
rack and floor shipping cover.

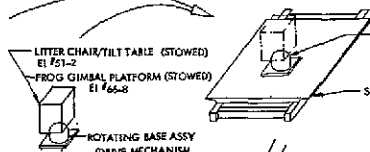
UNDERLOOR CARLING

STEP 1: PLACE RACK FRAMES WITH PREMOUNTED
EQUIPMENT ON RACK FRAME STANDS AND
INSTALL RACKS 3a & 3b EXPERIMENT PANELS
The rack frames arrive at the Level IV site with
the rack subsystems pre-mounted. This includes
the RAU's, power systems, EPDP, harnesses, and
plumbing. After the rack frames are positioned
on the rack frame stands, the Rack 3a & 3b ex-
periment modules are mounted into the rack frame
and the appropriate interfaces made. This in-
cludes electrical harnesses, command and data
bus and fluid line connections.

NOTE: THE MOUNTING PLATE FOR THE
MICROSCOPE ARTICULATING
ARM (EI #66-10) STOWED WILL
BE BOLTED ON THE UPPER RACK
FRAME.



STEP 4: CONNECT GSE LINES, CABLES AND PLUMBING
After the experiment racks, base, and
transport braces are secured to the floor seg-
ment, the appropriate experiment checkout and
support equipment are installed. These include
power and data cables and fluid line connections
which are connected to their respective interfaces.



ROTATING BASE ASSY
EI #49-4
(DRIVE MECHANISM &
TILTING BASE PLATE)

STEP 2: PLACE ROTATING/TILTING BASE ASSEMBLY
ON SPACELAB FLOOR SEGMENT AND ASSEMBLE
LITTER CHAIR-TILT TABLE OR GIMBAL PLATFORM
ON BASE FOR EXPERIMENT TESTS

The floor segment arrives at the Level IV site with
the floor segment subsystems pre-mounted. This in-
cludes the harnesses, EPDP, and plumbing. After
the rotating/tilting base assembly is mounted on the
floor segment, the litter chair-tilt table or the gimbal
platform will be assembled on the rotating/tilting
base for occlusion/rotation tests. The appropriate
electrical and fluid interfaces will then be made.
The rotating/tilting base, the litter chair-tilt table,
and the gimbal platform, when delivered to the Level
IV site, the ready for direct installation onto the
floor segment and only minor subsystem equipment
need be installed. The litter chair, tilt table, and
gimbal platform are stowed when not mounted
on the rotating base for occlusion/rotation tests.

STEP 3: PLACE AND SECURE EXPERIMENT MOUNTED
RACK FRAMES 3a & 3b ON SPACELAB FLOOR
SEGMENT AND INSTALL RACK AND FLOOR
TRANSPORT PLATFORM AND RACK AND
FLOOR SUPPORT BRACES KIT

The experiment mounted rack frames 3a & 3b are
installed on the Spacelab floor segment together
with the rack and floor transport platform and
rack and floor support braces kit. At this time
the rack to rack and rack to floor segment inter-
faces are made. This includes electrical harnesses,
command and data bus and fluid line connections.

CARDIOVASCULAR
INSTRUMENT PANEL
ASSEMBLY EI #49-3

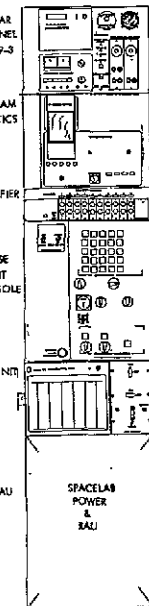
ECHOCARDIOGRAM
& TV CAMERA/OPTICS
EI #49-1

ISOLATION AMPLIFIER
EI #66-10

ROTATING BASE & EXPERIMENT
CONTROL CONSOLE
EI #49-5

REFRIGERATION UNIT
(SLIDE OUT)
& GAS SHUTOFF
EI #8-3b

SPACELAB POWER & RAU



RACK # 3b EQUIPMENT

SEQUENCE OF
INSTALLATION

- | | |
|--|----|
| CARDIOVASCULAR
INSTRUMENT PANEL
ASSEMBLY EI #49-3 | 6. |
| ECHOCARDIOGRAM
& TV CAMERA/OPTICS
EI #49-1 | 5. |
| ISOLATION AMPLIFIER
EI #66-10 | 4. |
| ROTATING BASE & EXPERIMENT
CONTROL CONSOLE
EI #49-5 | 3. |
| REFRIGERATION UNIT
(SLIDE OUT)
& GAS SHUTOFF
EI #8-3b | 2. |
| SPACELAB POWER & RAU | 1. |

Figure 3-36, Life Sciences Ground Assembly Flow, Site #1

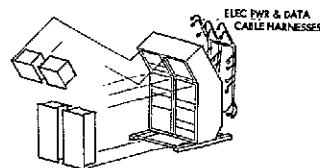
3-77, 3-78

SD 78-SR-0009-2

FOLDOUT FRAME 1

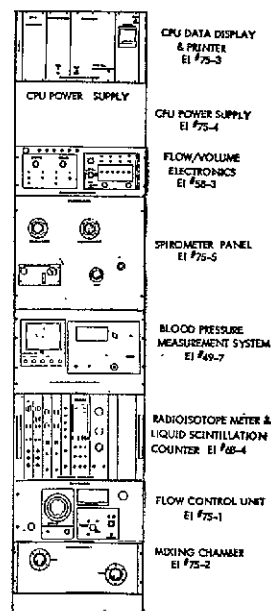
STEP 1: PLACE RACK FRAMES WITH PREMOUNTED EQUIPMENT ON RACK FRAME STANDS AND INSTALL RACKS 4a & 4b EXPERIMENT MODULES

The double rack frame arrives at the Level IV site with the rack subsystems premounted. This includes the RAU's, power system, EPDS, harnesses, and plumbing. After the double rack frame is positioned on the rack frame stand, the Rack 4a & 4b experiment modules are mounted into the rack frames and the appropriate electrical and fluid interface mode. This includes electrical harnesses, command and data bus and fluid line connections.



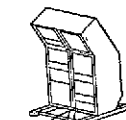
RACK 4a EQUIPMENT

SEQUENCE OF INSTALLATION



STEP 2: CONNECT GSE LINES, CABLES AND PLUMBING

After the experiment racks and transport boxes are secured, the appropriate experiment checkout and support equipment are installed. These include power and data cables and fluid line connections which are connected to their respective interfaces.



POWER & PERIPHERAL EQUIPMENT

CHECKOUT CONSOLES

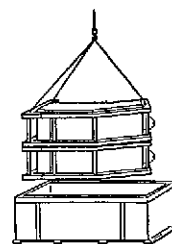
STEP 3: EXPERIMENT CHECKOUT AND INTERFACE VERIFICATION

After GSE connection the experiments will undergo checkout and interface verification. The peripheral equipment and checkout console will operate and control the experiments, perform fault isolation and trouble shooting, data record and display, and simulate experiment functions.

STEP 4: PREPARE FOR TRANSPORT

After completion of interface verification the racks will be prepared for shipment. Experiment racks will be loaded into the double rack handling and transport kit shipping containers.

LOAD EXPERIMENT RACKS INTO CONTAINER

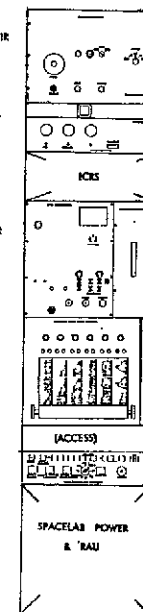


FOLDOUT FRAME 2

RACK 4b EQUIPMENT

SEQUENCE OF INSTALLATION

9. RADIOISOTOPE AIR MONITOR
EI #78-28
8. INTERFACE PANEL
EI #58-4
7. ICBS PANEL
6. MASS SPECTROMETER
EI #58-1
5. PNEUMOTACHOMETER
EI #58-2
4. 6-CHANNEL STRIP CHART RECORDER
EI #58-5
3. URINE ACCESS
2. URINE ELEC. ANAL
EI #77-1
1. SPACELAB POWER & RAU



NOTE: 5-GAS BOTTLE ASSY
BEHIND PANELS (58-4)
(INSTALLED BEHIND
ICBS PANEL)

Figure 3-37, Life Sciences Ground Assembly Flow, Site #2

3-79, 3-80

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GROUND ASSEMBLY FLOW, SITE 3 ORIGINAL PAGE IS OF POOR QUALITY

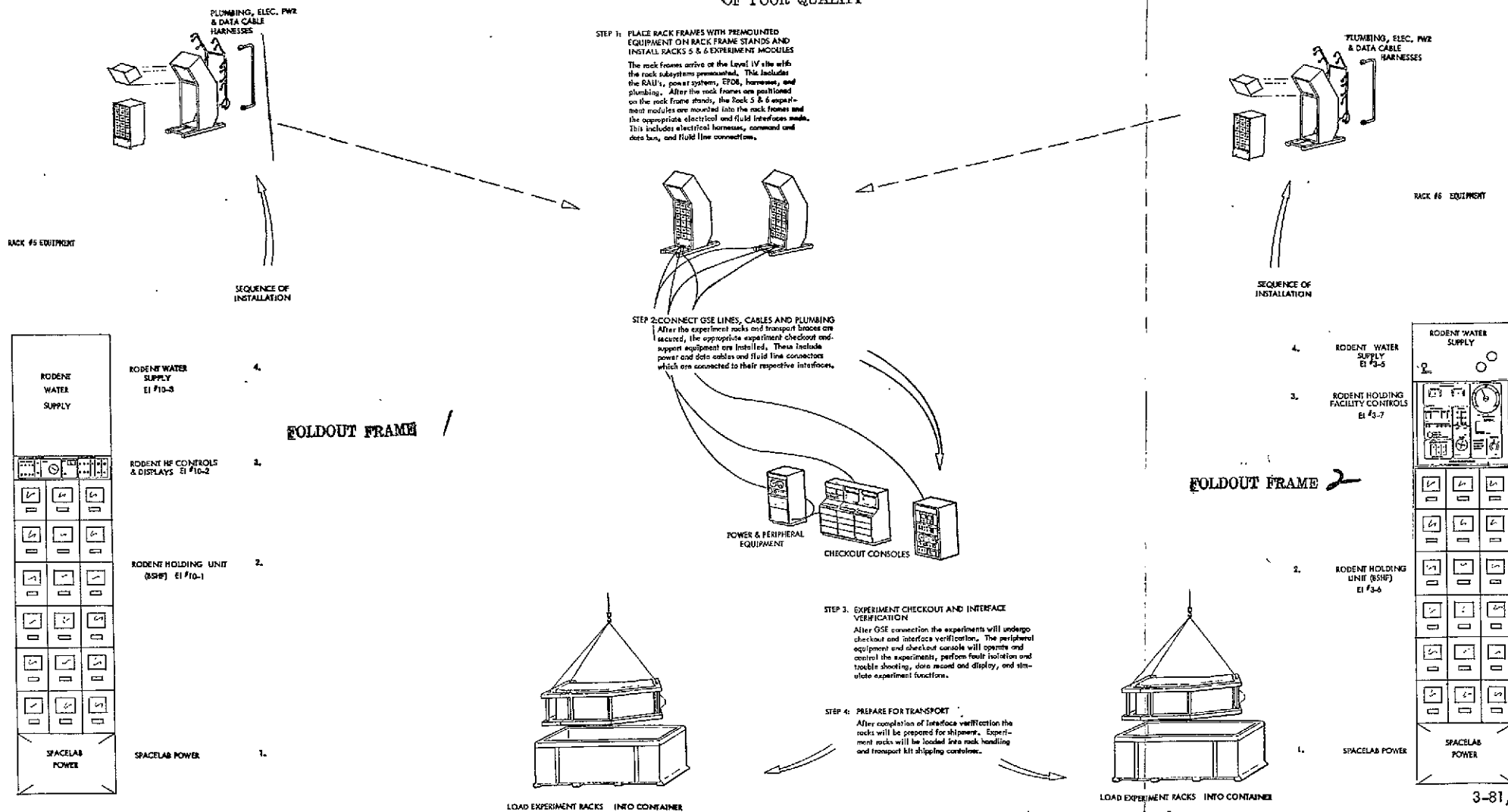
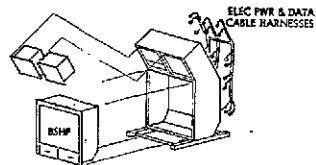


Figure 3-38, Life Sciences Ground Assembly Flow, Site #3

SITE #4 RACKS 7a & 7b

STEP 1: PLACE RACK FRAMES WITH PREMOUNTED EQUIPMENT ON RACK FRAME STANDS AND INSTALL RACKS 7a & 7b EXPERIMENT MODULES

The double rack frame arrives at the Level IV site with the rack subsystems premounted. This includes the RAD's, power systems, EPDS, harnesses, and plumbing. After the double rack frame is positioned on the rack frame stand, the Rack 7a & 7b experiment modules are mounted into the rack frames and the appropriate electrical and fluid interfaces made. This includes electrical harnesses, command and data bus and fluid line connections.



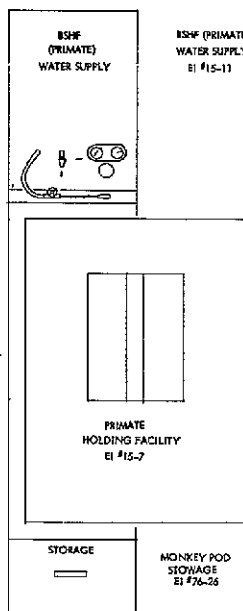
ELEC PWR & DATA CABLE HARNESSSES

RACK 7a EQUIPMENT

RACK 7b EQUIPMENT

SEQUENCE OF INSTALLATION

3.

PRIMATE HOLDING FACILITY
EI #15-7

2.

1.

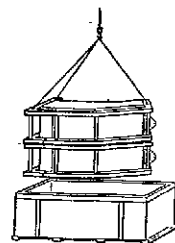
FOLDOUT FRAME

STEP 2: CONNECT GSE LINES, CABLES AND PLUMBING

After the experiment racks and transport braces are secured, the appropriate experiment checkout and support equipment are installed. These include power and data cables and fluid line connectors which are connected to their respective interfaces.

POWER & PERIPHERAL EQUIPMENT

CHECKOUT CONSOLES

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LOAD EXPERIMENT RACKS INTO CONTAINER

STEP 4: PREPARE FOR TRANSPORT

After completion of interface verification the racks will be prepared for shipment. Experiment racks will be loaded into shipping container.

STEP 3: EXPERIMENT CHECKOUT AND INTERFACE VERIFICATION

After GSE connection the experiments will undergo checkout and interface verification. The peripheral equipment and checkout console will operate and control the experiments, perform fault isolation and trouble shooting, data record and display, and simulate experiment functions.

SEQUENCE OF INSTALLATION

3.

2.

BLANK

AC INVERTER & POWER PANEL
EI #15-12PRIMATE HOLDING FACILITY CONTROLS
EI #15-4

ICRS PANEL

ICRS

FOLDOUT FRAME 2

1.

SPACELAB POWER

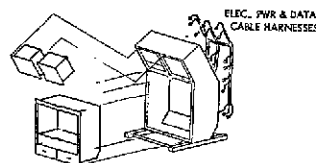
SPACELAB POWER

Figure 3-39, Life Sciences Ground Assembly Flow, Site #4

3-83, 3-84

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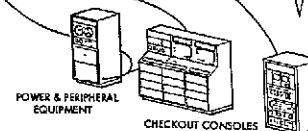
The double rack frame arrives at the Level IV site with the rack subsystems pre-mounted. This includes the RAU's, power systems, EPDS, harnesses, and plumbing. After the double rack frame is positioned on the rack frame stand, the Rack 3's & 8's experiment modules are mounted into the rack frames and the appropriate electrical and fluid interfaces made. This includes electrical harnesses, command and data bus and fluid line connections.



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OF POOR QUALITY

SEQUENCE OF INSTALLATION

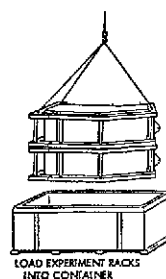
STEP 2: CONNECT GSE LINES, CABLES AND PLUMBING
After the experiment racks and transport braces are secured, the appropriate experiment checkout and support equipment are installed. These include power and data cables and fluid line connectors which are connected to their respective interfaces.



STEP 3: EXPERIMENT CHECKOUT AND INTERFACE VERIFICATION

After GSE connection the experiments will undergo checkout and interface verification. The peripheral equipment and checkout console will operate and control the experiments, perform fault isolation and trouble shooting, data record and display, and simulate experiment functions.

STEP 4: PREPARE FOR TRANSPORT
After completion of interface verification the racks will be prepared for shipment. Experiment racks will be loaded into shipping containers.



SEQUENCE OF INSTALLATION

FOLDOUT FRAME

FOLDOUT FRAME

Figure 3-40, Life Sciences Ground Assembly Flow, Site #5

3-85, 3-86

SD 78-SR-0009-2

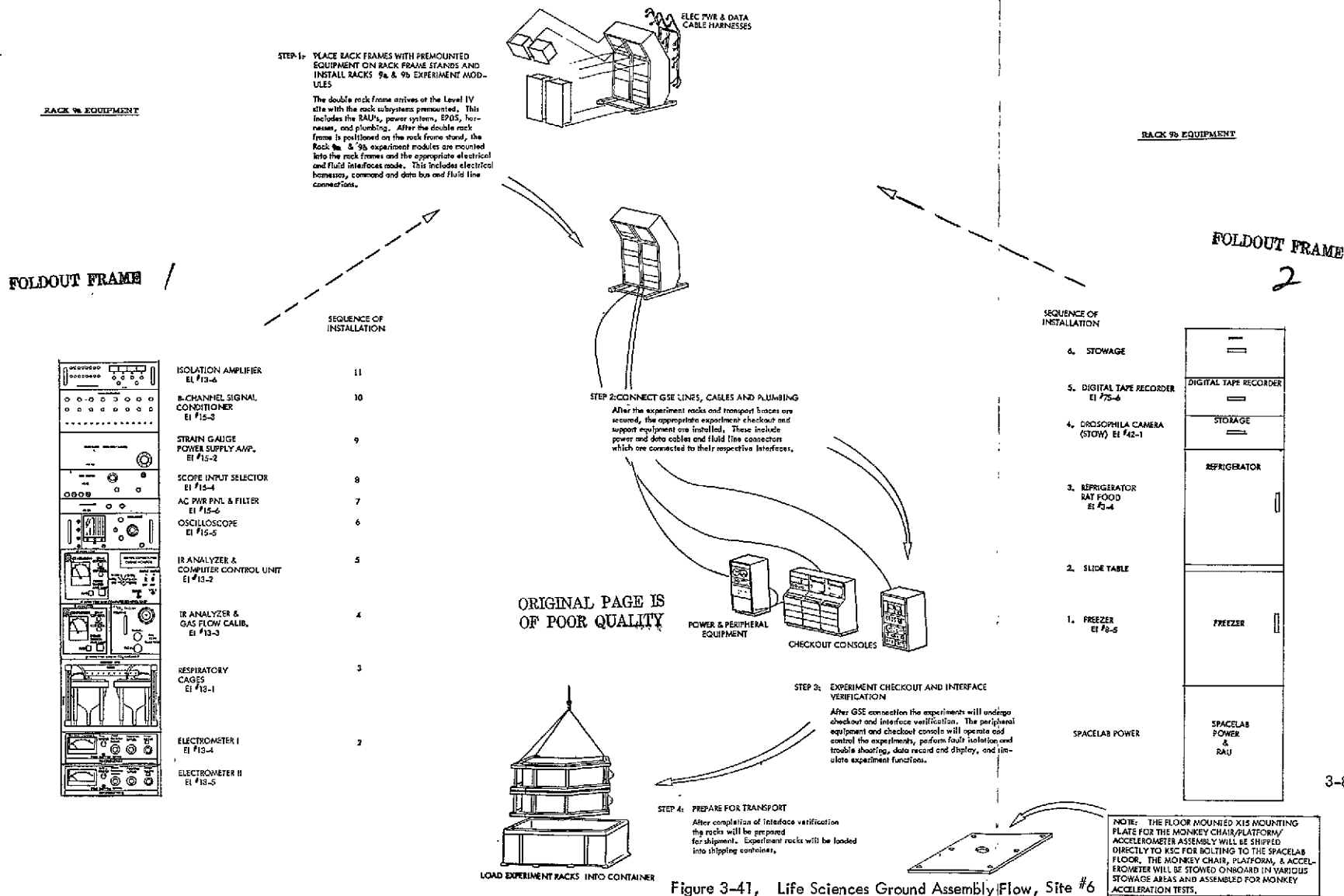


Figure 3-41, Life Sciences Ground Assembly Flow, Site #6

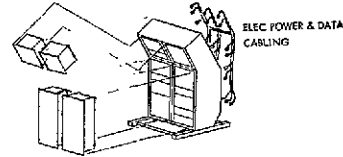
SITE #7 RACKS 10a & 10b

RACK #10a EQUIPMENT

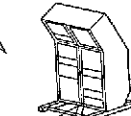
RACK #10b EQUIPMENT

STEP 1: PLACE RACK FRAMES WITH PREMOUNTED EQUIPMENT ON RACK FRAME STANDS AND INSTALL RACKS 10a & 10b EXPERIMENT MODULES

The double rack frame arrives at the Level IV site with the rack subsystems pre-mounted. This includes the RAU's, power system, EPDS, batteries, and plumbing. After the double rack frame is positioned on the rack frame stand, the Rack 10a & 10b experiment modules are mounted into the rack frames and the appropriate electrical and fluid interfaces made. This includes electrical harnesses, command and data bus and fluid line connections.



ELEC POWER & DATA CABLEING



STEP 2: CONNECT GSE LINES, CABLES AND PLUMBING

After the experiment racks and transport braces are received, the appropriate equipment checkout and support equipment are installed. These include power and data cables and fluid line connectors which are connected to their respective interfaces.

POWER & PERIPHERAL EQUIPMENT

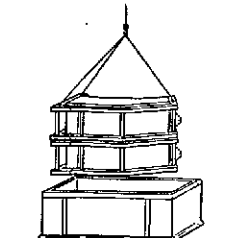
CHECKOUT CONSOLES

STEP 3: EXPERIMENT CHECKOUT AND INTERFACE VERIFICATION

After GSE connection the experiments will undergo checkout and interface verification. The peripheral equipment and checkout console will operate and control the experiments, perform fault isolation and trouble shooting, data record and display, and simulate experiment functions.

STEP 4: PREPARE FOR TRANSPORT

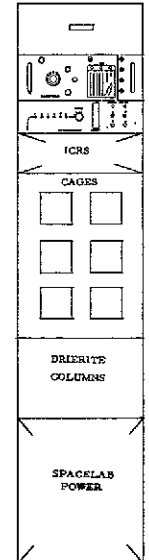
After completion of interface verification the racks will be prepared for shipment. Experiment racks will be loaded into shipping containers.



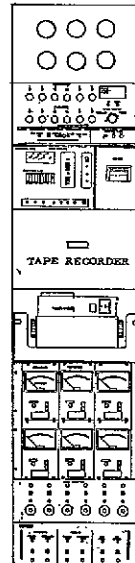
LOAD EXPERIMENT RACKS INTO CONTAINER

SEQUENCE OF INSTALLATION

6. METABOLISM RAT WATER SUPPLY/ACCESS EI #59-9
5. OSCILLOSCOPE EI #59-14
4. AIR (GAS) ANALYZER EI #59-5
3. ICBS PANEL
2. METABOLISM CAGES & CAGES EI #59-7
1. DUETTE COLUMNS & CAGE CONTROL EI #59-12
- SPACELAB POWER



FOLDOUT FRAME 2

RAT CAGES
AIR FILTERS
EI #59-11METABOLIC KCVR/
PYROGEN TUNING
EI #59-4

OSCILLO. SELECT EI #59-10

DATA LOGGER
EI #59-1TAPE RECORDER (ANALOG)
EI #59-2TORSION BALANCE (SLIDE UNIT)
EI #59-2METABOLISM
FLOW METERS
EI #59-3CAGE AIR FLOW CONTROL
EI #59-6POWER SUPPLY
EI #59-8SEQUENCE OF
INSTALLATION

9.

8.

7.

6.

5.

4.

3.

2.

1.

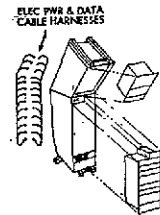
FOLDOUT FRAME 1

Figure 3-42, Life Sciences Ground Assembly Flow, Site #7

GROUND ASSEMBLY FLOW, SITE 8

SITE #8 RACKS #11 & 12

RACK #11 EQUIPMENT

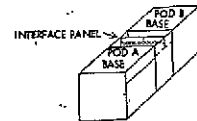


STEP 1: PLACE RACK FRAMES WITH PREMOUNTED EQUIPMENT ON RACK FRAME STANDS AND INSTALL RACKS 11 & 12 EXPERIMENT PANELS

The rack frame arrives at the Level IV site with the rack subsystems premounted. This includes the RAUS, power system, EPDS, and plumbings. After the rack frame is positioned on the rack frame stand, the Rack 11 & 12 experiment panels are routed into the rack frame and the appropriate interfaces made.

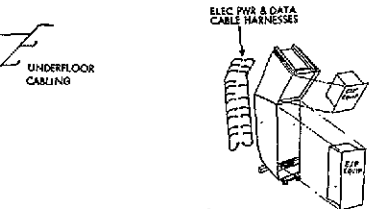
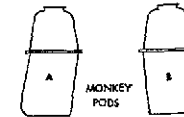
FLOOR SEGMENT EQUIPMENT

MONKEY POD DRAWER	EI #76-27
HAZ COLLECTION/FILTER	EI #76-29
FEEDER/WATER CTRL	EI #76-31
CAMERA STORAGE	EI #76-32
TEMPERATURE MULTIPLEX	EI #76-19
WATER STORAGE	EI #76-14
PUMP ASSEMBLY	EI #76-33 (UNDER FLOOR)



STEP 2: PLACE MONKEY PODS A & B AND POD BASES A & B ON SPACELAB FLOOR SEGMENT AND INSTALL EXPERIMENT PANELS

The floor segment arrives at the Level IV site with the floor segment subsystems premounted. This includes the harnesses, EPDS, and plumbings. After the monkey pods and bases are received on the floor segment, the experiment panels are mounted into the pod bases, the pump assembly is mounted under the floor, and the appropriate electrical and fluid interfaces made. The monkey pods and bases, when delivered to the Level IV site, are ready for direct installation onto the floor segment and only minor subsystem equipment need be installed.



STEP 3: PLACE AND SECURE EXPERIMENT MOUNTED RACK FRAMES 11 & 12 ON SPACELAB FLOOR SEGMENT AND INSTALL RACK AND FLOOR TRANSPORT BRACES KIT

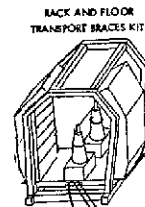
The experiment mounted rack frames 11 & 12 are installed on the Spacelab floor segment together with the rack and floor transport braces kit. At this time the rack to rack and rack to floor segment interfaces are made. This includes electrical harnesses, ground and data bus and fluid line connectors.

SEQUENCE OF INSTALLATION

SEQUENCE OF INSTALLATION	
10	PERFUSION PUMP (STOW) EI #76-1
9	DROGOMETER CAMERA (STOW) EI #76-2
8	OSCILLOSCOPE SWITCH SELECTOR EI #76-7
7	DEMULATOR PATCH EI #76-6
6	TELEMETRY RECEIVER POD B EI #76-4
5	DEMULATOR POD B EI #76-5
4	UPPER POD A FLOW CONTROL PANEL EI #76-30
3	TELEMETRY RECEIVER POD A EI #76-16
2	DEMULATOR POD A EI #76-17
1	UPPER POD B FLOW CONTROL PANEL EI #76-11

STEP 6: PREPARE FOR TRANSPORT

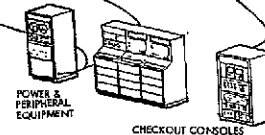
After completion of interface verification the rack and floor segment will be prepared for shipment.



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STEP 4: CONNECT GSE LINES, CABLES AND PLUMBING

After the experiment racks, monkey pods and bases, and transport braces are secured to the floor segment, the appropriate experiment checkout and support equipment are installed. These include power and data cables and fluid line connectors which are connected to their respective interfaces.



STEP 5: EXPERIMENT CHECKOUT AND INTERFACE VERIFICATION

After GSE connection the experiments will undergo checkout and interface verification. The participant equipment and checkout console will operate and control the experiments, perform fault isolation and trouble shooting, data record and display, and simulate experiment functions.

11	CONTROL CALIB. GASES EI #76-23
10	CALIB GAS CTRL PANEL EI #76-18
9	20-CHANNEL SIGNAL CONDITIONER EI #76-2
8	BUFFER AMP POD A EI #76-19
7	BUFFER AMP POD B EI #76-8
6	HEART RATE/DIFF. PRESS. M.S., DVM EI #76-9
5	MASS SPECTROM. & SAMPLE VALVES EI #76-20
4	MASS SPECTROM. CONTROLS EI #76-21
3	LOWER BODY NEGATIVE PRESS (LBNP) PANEL EI #76-10
2	BARATRON AMP. EI #76-22
1	PART. PRESS. RATIO EI #76-24

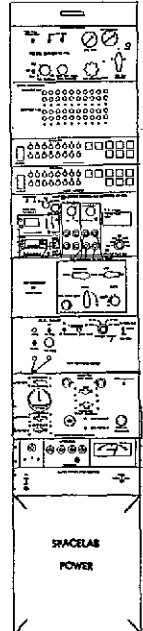
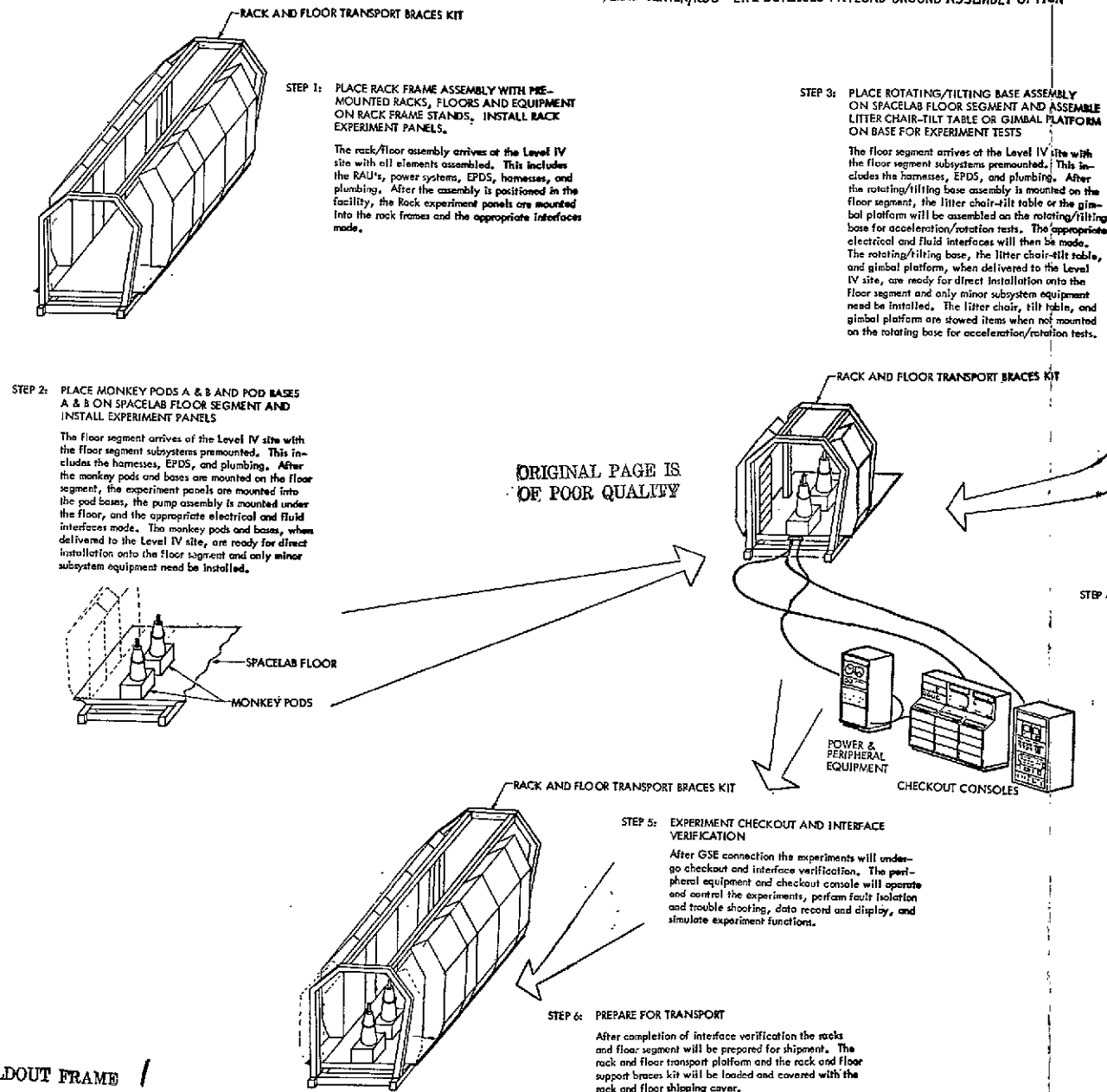


Figure 3-43, Life Sciences Ground Assembly Flow, Site #8



FOLDOUT FRAME 1

FOLDOUT FRAME 2

Figure 3-44. Life Sciences Ground Assembly Flow, Lead Center Assembled Payload



Experiment System Interactions

Interface verification of installed Life Science experiment equipment will be performed initially on individual experiment rack modules and later on integrated payloads during combined payload checkout. For the most part, each of the experiments operate independently of the others. They do not interface nor interfere with each other. After all end items of an experiment are installed, tests will be conducted to verify connector and wire harness/fluid line integrating. All end items and supporting equipment are assumed to arrive healthy, therefore, these tests will be primarily concerned with verifying data signals to interconnected experiment end items, CDMS simulator, data recorder, printer, and CRT. Typically, testing will be accomplished by observing waveforms/status lists on a CRT and comparing these outputs to a predetermined signal that occurs in response to a specified command. Testing of CDMS signals through the RAU's will use a CDMS simulator. The observation of signal waveforms displayed on a CRT connected to the output data stream will assure that the correct response to a command has occurred.

Man-Machine Interfaces

To verify operation of some Life Science experiments, certain Principal Investigator (PI) furnished animal and human simulators will be used. These essentially consist of signal generators which serve as a human physiological simulators, frog nerve signal simulator, rat bio-telemetry simulator, oculographic (EOG) simulator, mass spectrum analog data simulator, rat/cage temperature output simulator, and the monkey physiological simulator. For testing of the floor mounted Experiment 49 rotating base assembly with its drive mechanism and tilting base plate, the stowed litter chair/tilt table (Expt. 49/51) and the stowed frog gimbal platform (Expt. 66) will be used. The litter chair/tilt table and frog gimbal platform are removed from storage and mounted on the rotating base for acceleration/rotation tests.

The monkey physiological simulator will be used in the monkey pod (Expt. 76) verification tests. After the monkey pods and bases are mounted to the floor segment, the experiment modules are mounted into the pod bases, the pump assembly is mounted under the floor, and the appropriate electrical and fluid interfaces made. The monkey pods and bases, when delivered to the Level IV site, are ready for direct installation onto the floor segment and only minor subsystem equipment need be installed.

On-Pad Operations

The Life Sciences live test specimens (rodents, primates, and frogs) will be carried during ascent (and descent) in the Orbiter mid deck stowage until the Spacelab has been determined to be stabilized and habitable (approximately T+3 hours). On-orbit, the specimens will be moved through the tunnel into the Spacelab and installed in the rodent and primate holding facilities.



Software Requirements

There are no Life Science experiment or group of experiments requiring experiment unique application programs in the CDMS computer. Six experiments (Exp. 13, Muscle Protein Degradation, Exp. 15, Monkey Activity Change, Exp. 49, Human Cardiovascular Alteration, Exp. 58, Human Pulmonary Function, Exp. 66, Otolith Response Adaption, and Exp. 76, Monkey Cardiovascular Dynamics) do provide outputs to the CDMS in three ways: (1) data signals through the RAU's to the data bus, (2) data signals directly into the video channel, and (3) data signal outputs to the High Data Rate Multiplexer (HDRM). Standard Spacelab software control of CDMS operations is required during subsystem interface verification.

Experiment Installation and Test Sequences (Waterfalls)

A series of Level IV installation and test sequences reflecting the procedures previously described were prepared and timed in a waterfall format. These were prepared to serve as the basis for eventual equipment utilization times, and manpower estimates for study baseline cost data.

Mini-Center Waterfalls

The Mini-center sequences were based on the following guidelines: (1) Spacelab equipment is available at an integration site as required, i.e. racks, common equipment, floor segments, etc., (2) a full complement of experiment end items are on hand to allow complete checkout of rack installations, (3) all end items are operative upon receipt, subject to receiving inspection, (4) non-functional experiment hardware such as storage space does not require level IV integration verification, and (5) installation is rack oriented rather than experiment oriented.

Mini-Center One. A floor segment is required in addition to rack 3 to complete the assembly and allow verification of the installation. The rotating base on which the tilt table is mounted is attached to the floor assembly near rack 3, and power and data cables are provided through the center aisle connect bracket (CACB). The waterfall, Figure 3-45, was prepared for Mini-Center 1 assuming no interference between the installation of the rotating base, and the installation of the rack 3 mounted end items. The tilt table and rotating base assembly is shared by experiments 49 and 51 and the rotating base is also used for installation of the Gimballed Frog Platform to perform experiment 66. Verification of all Level IV connections can be accomplished by using the rotating base in conjunction with the tilt table and gimballed frog platform and verifying the functions of all experiment 49 and 66 end items. Therefore, two verification test blocks are shown on the waterfall.

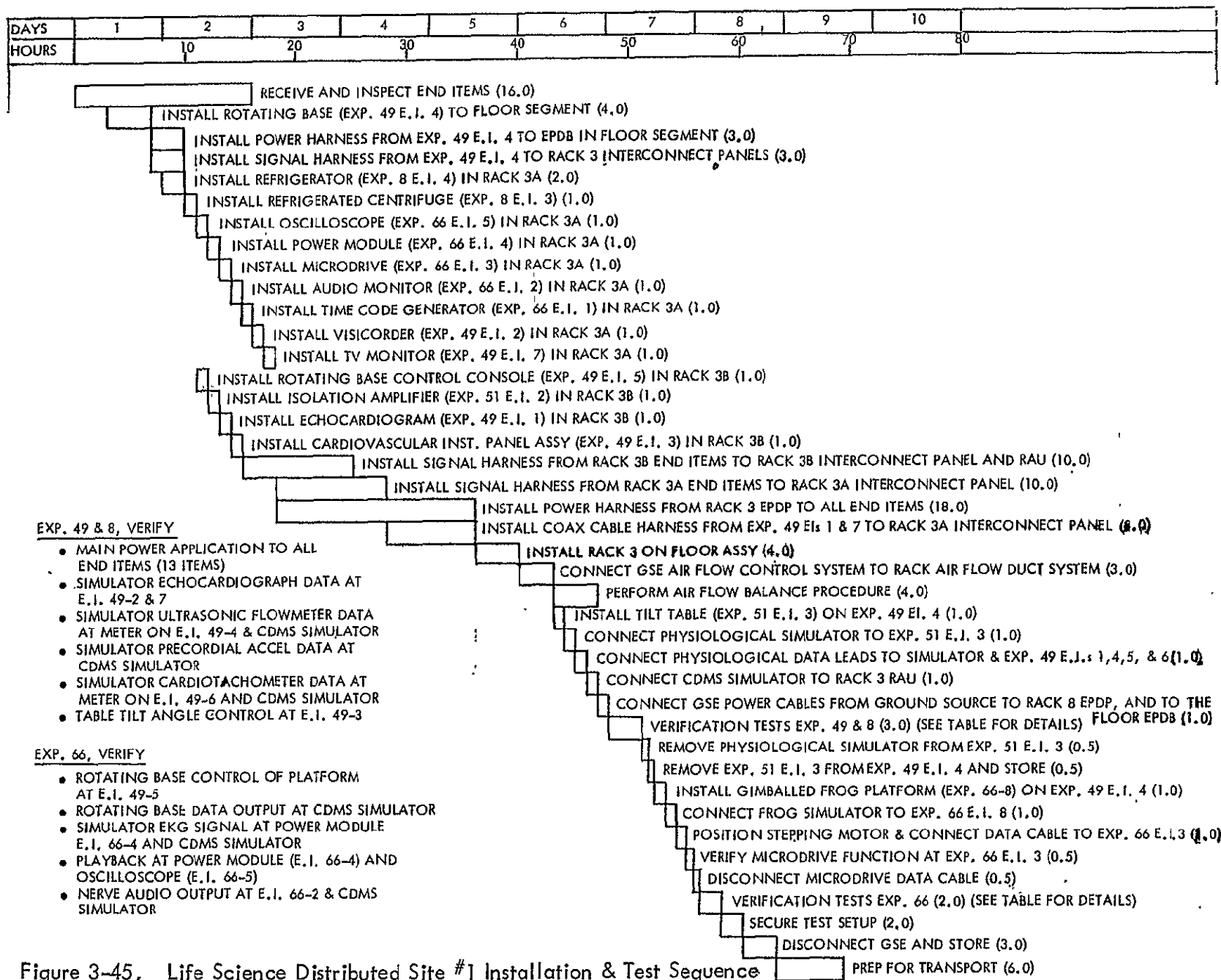


Figure 3-45, Life Science Distributed Site #1 Installation & Test Sequence



Mini-Center Two. At mini-center two of one double rack, rack 4, is involved. No conflict is anticipated when installing end items in both halves of the rack. The rack primarily contains end items from experiments 58 and 75. The mass spectrometer, end item 58-1, and the strip recorder end item 58-5 are shared by several other experiments. Verification of the rack 4 end items requires a human test subject. The waterfall is shown in Figure 3-46.

Mini-Center Three. Both racks 5 and 6 are assembled at this mini-center. Both contain rodent holding facilities and related equipment. These holding facilities are used by most of the experimentors requiring rodents. Verification of each rack installation is simple and it is assumed can be done in parallel, as shown in Figure 3-47.

Mini-Center Four. Rack 7 contains the primate holding facility and associated equipment. Although designed for primates, the equipment and the installation/verification process are comparable to the rodent holding facilities of racks 5 and 6, and could be assembled at the same mini-center. The integration sequence is shown in Figure 3-48.

Mini-Center Five. Rack 8 consists of mostly stowage areas and the surgical work bench which is shared by many experiments. Figure 3-49 shows how this rack could be easily assembled in conjunction with another mini center such as three or four.

Mini-Center Six. This site activity (Figure 3-50) consists of the tasks to install the equipment in Rack 9. The floor mounted X-15 mounting plate for the monkey chair/platform/accelerometer assembly will be shipped directly to KSC for bolting to the Space-lab floor, thus eliminating the need for shipping an independent floor segment for this single mechanical function.

Mini-Center Seven. Experiment 59 equipment is installed in Rack 10. There is no unique operations required for this mini-center. The sequence is shown in Figure 5-51.

Mini-Center Eight. Experiment 76 equipment is contained in Racks 11 and 12 and includes the monkey pod assembly. A floor segment is required as part of the experiment buildup, to allow mounting of the monkey pod assembly and other support equipment located in the floor. Checkout of the entire assembly is then possible, and the floor assembly with the racks attached will be shipped as an integral unit. Figure 3-52 presents the total sequence, which is the longest of all the mini-center flows.

Centralized Site Waterfalls

The waterfalls of level IV integration activities are identical for comparable lead center and KSC options. That is, the B-1 option sequence is identical to the C-1, B-3, C-3, and B-4 to C-4. In addition, the only difference between the B-1/C-1 options and the B-3/C-3 options is the combined payload checkout activities associated with the latter two options. The waterfall for these four options is shown in Figure 3-53. Note the last seven operations are applicable to options B-3 and C-3 only. This waterfall reflects the paralleling/integrating of the eight distributed site activities (previously described) to minimize GSE requirements and maximize personnel utilization.

3-99

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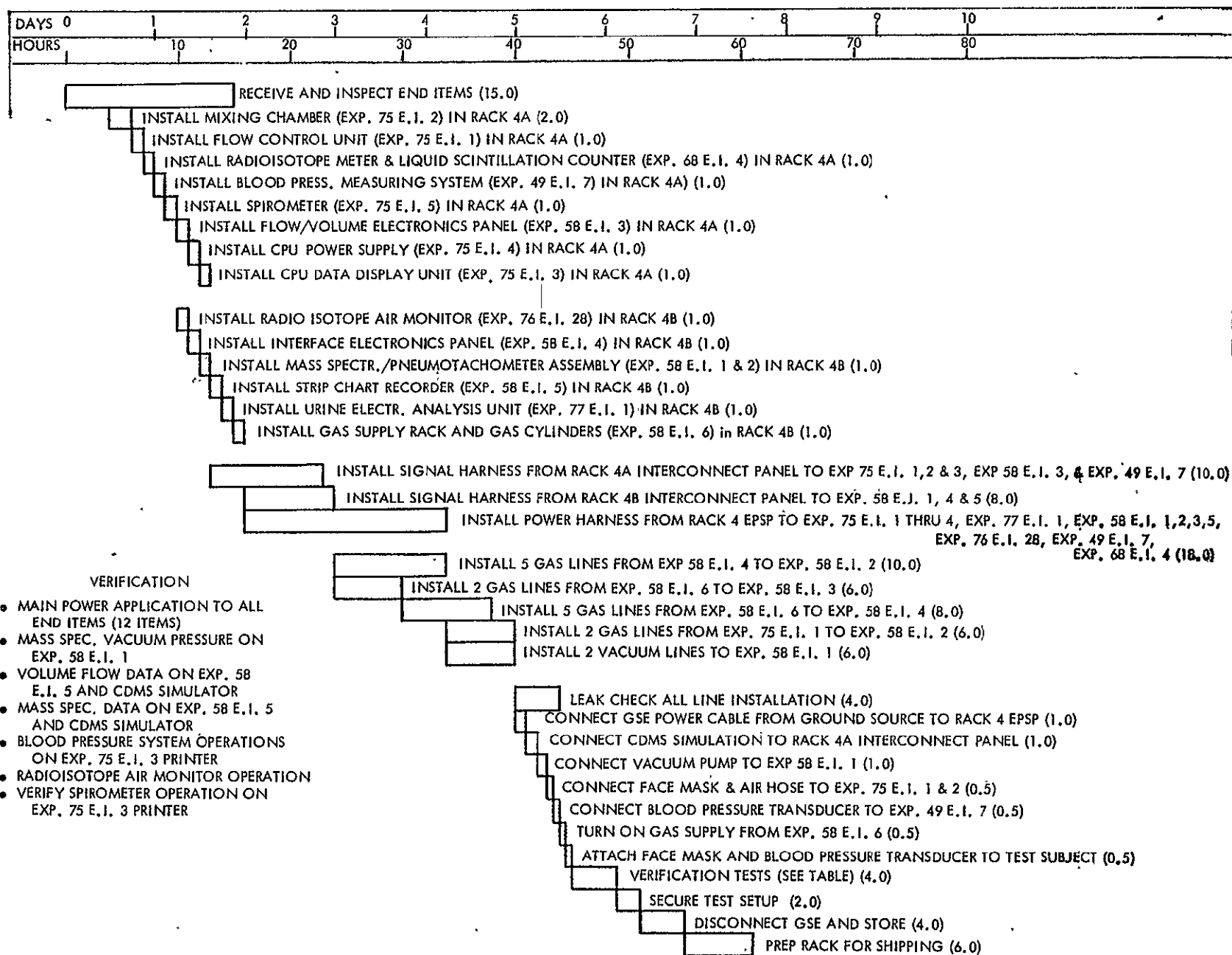


Figure 3-46, Life Science Distributed Site #2 Installation & Test Sequence

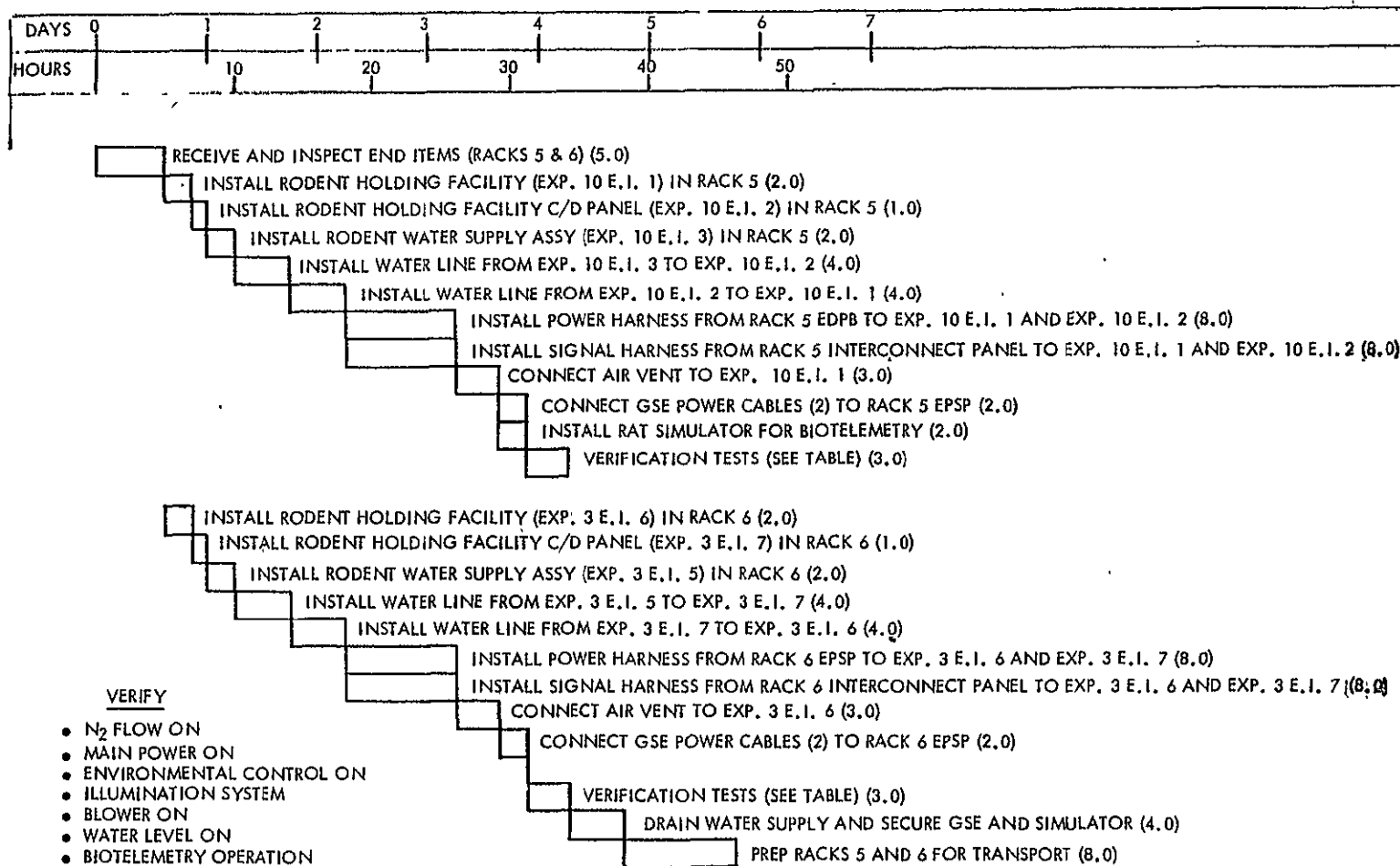


Figure 3-47, Life Science Distributed Site #3 Installation & Test Sequence

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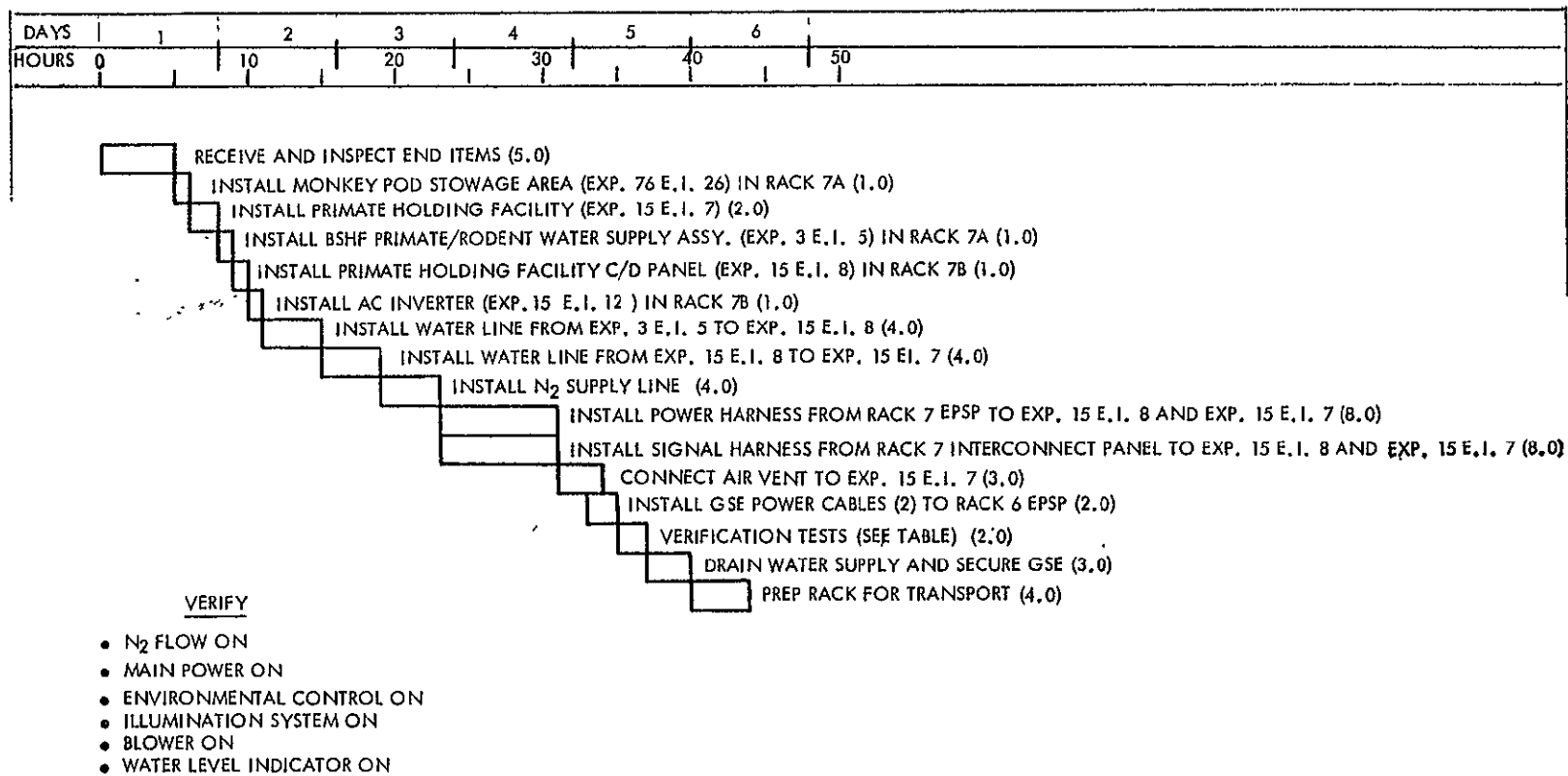


Figure 3-48, Life Science Distributed Site #4 Installation & Test Sequence

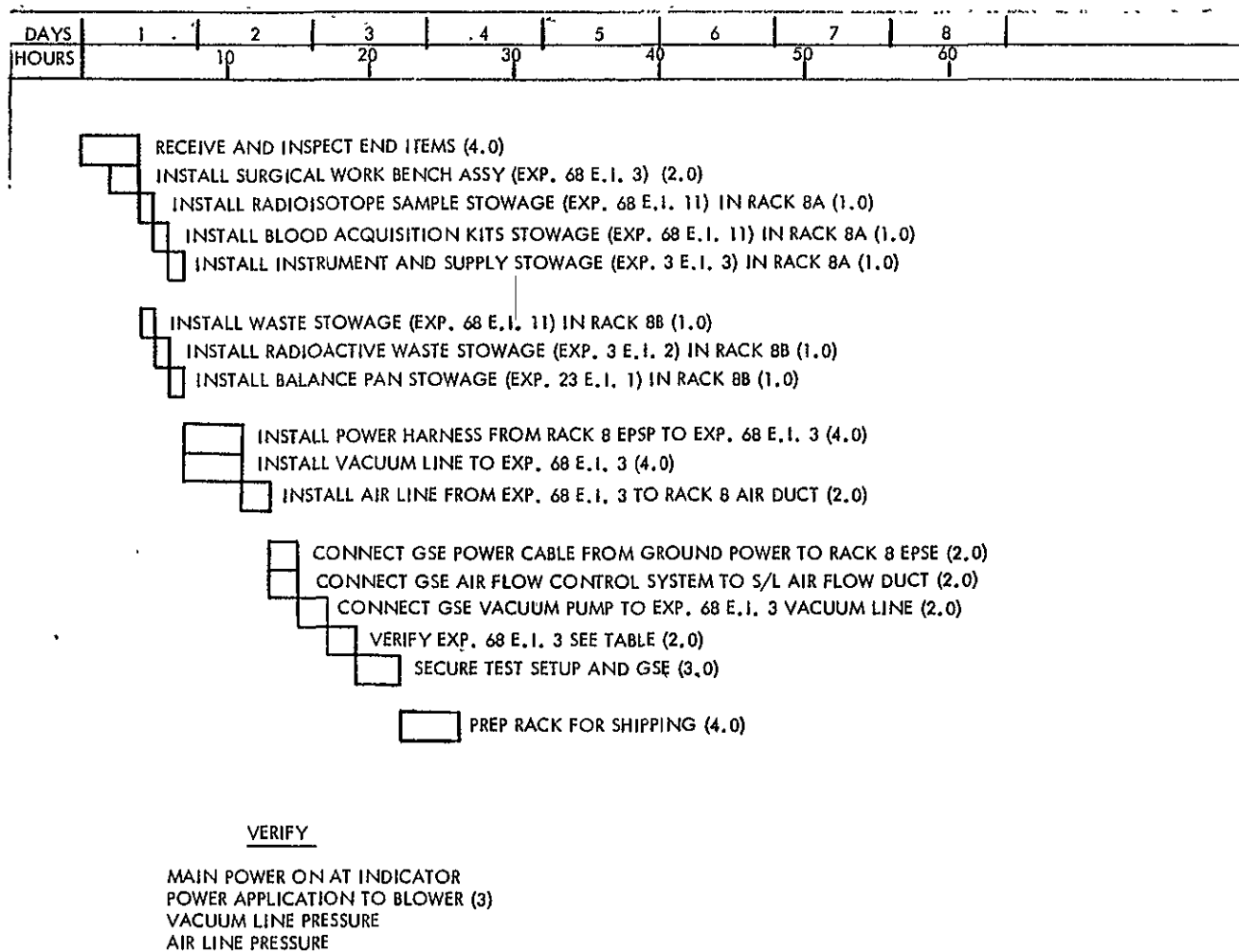


Figure 3-49, Life Science Distributed Site #5 Installation & Test Sequence

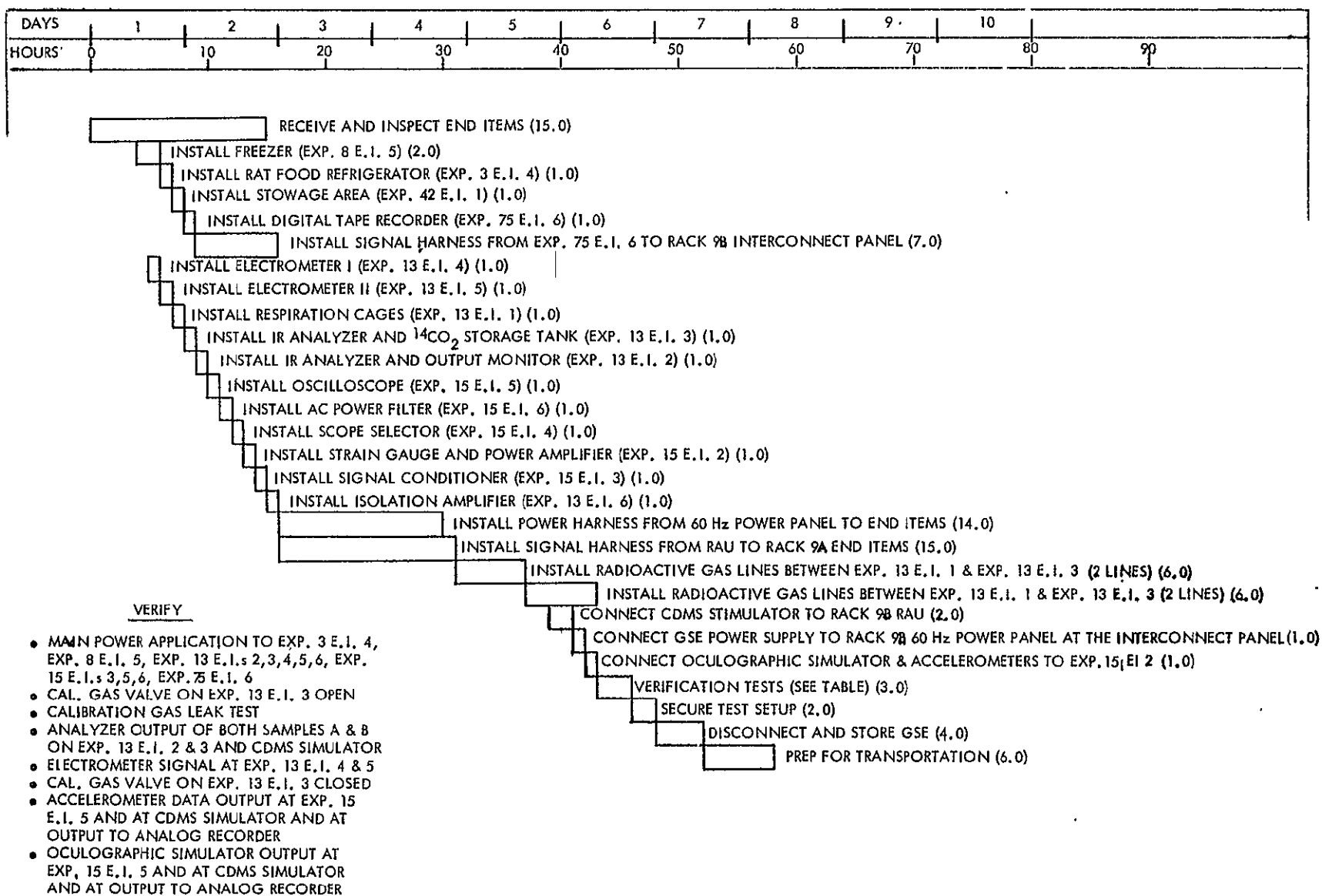


Figure 3-50, Life Science Distributed Site #6 Installation & Test Sequence

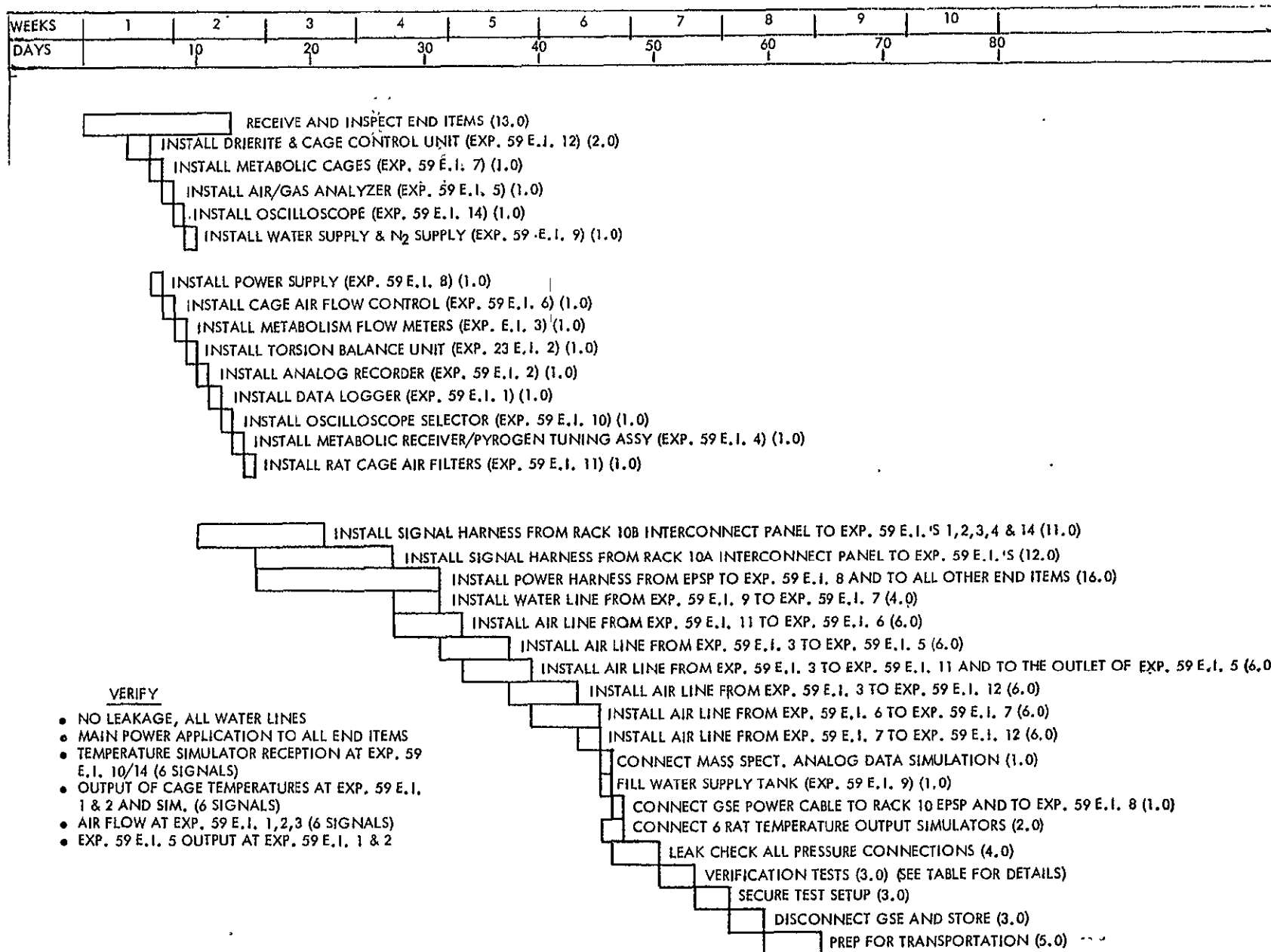


Figure 3-51, Life Science Distributed Site #7 Installation & Test Sequence

3-104

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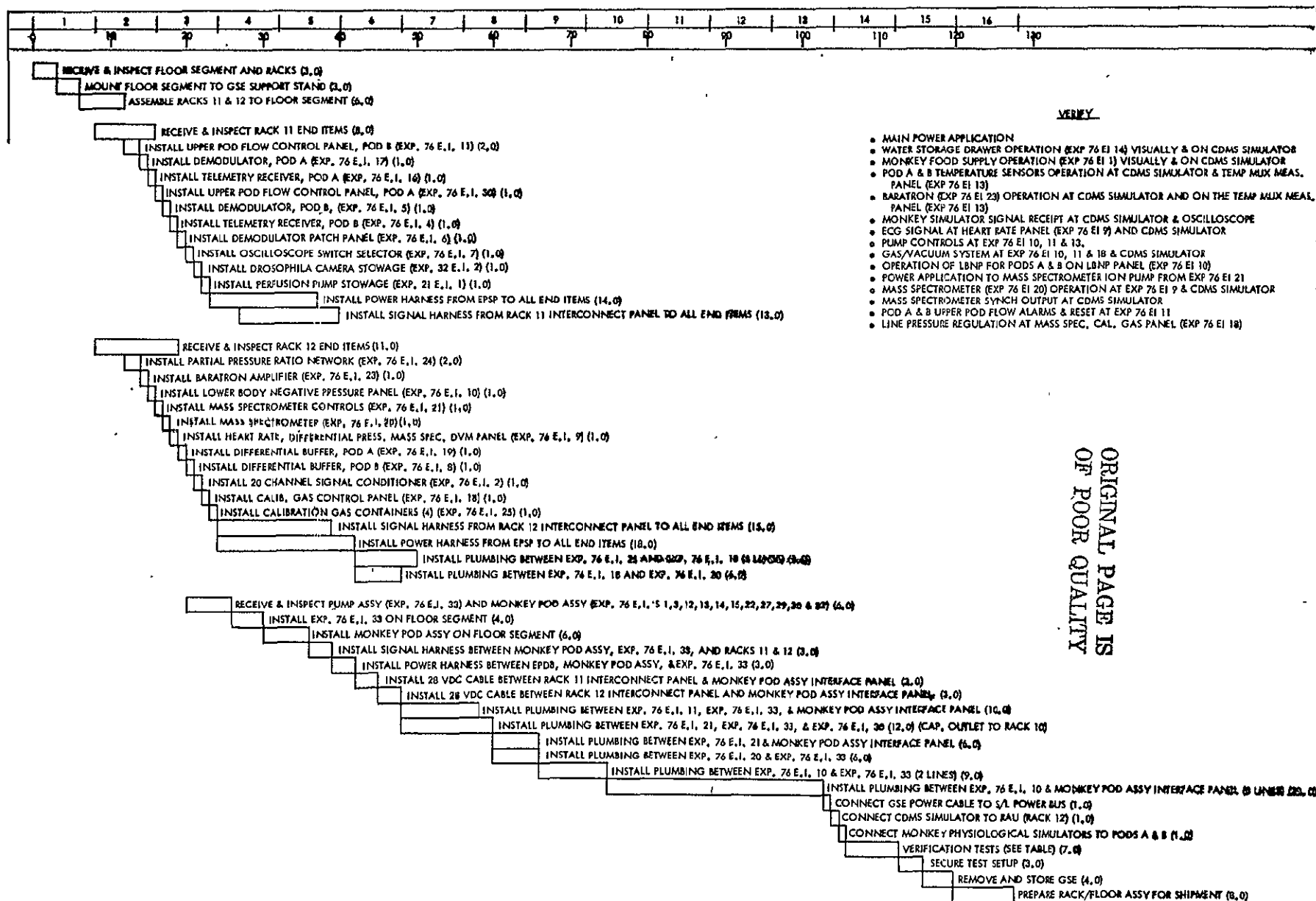
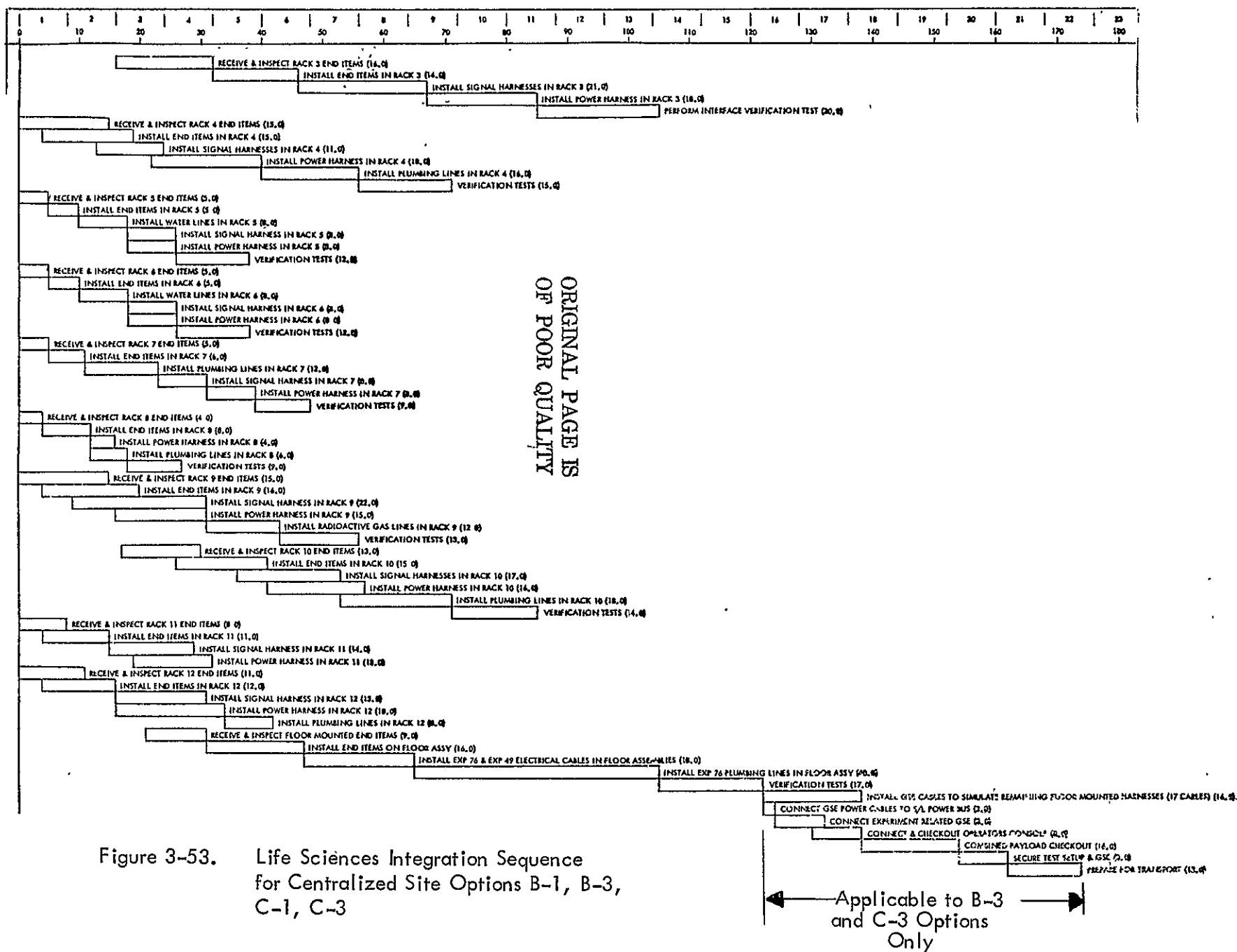


Figure 3-52, Life Science Distributed Site #8 Installation & Test Sequence





The waterfall for centralized site integration of the Life Sciences payload in the combined rack/floor configuration is shown in Figure 3-54. Note the portion of the waterfall that is applicable only to the B-5 option. The remainder of the waterfall is applicable to all three options (B-4, B-5, C-4). The unique B-5 activities pertain to the disassembly/disconnection of the core module portion from the experiment module portion of the configuration to facilitate over-the-road transportation with less than a twelve (12) foot width. This particular option (B-5) also imposes a requirement for reassembly in the level III stand at KSC. In the case of the B-4 or C-4 options, the Life Science payload can be introduced into KSC-STS operations in the level III/II main stand.

Post-Flight Rack-Floor-Experiment Deintegration Waterfall

One additional detailed waterfall was developed to establish overall hardware utilization times and manpower levels. This is the sequence for the post-flight deintegration of the racks, floors, experiment modules, wiring, and plumbing as shown in Figure 3-55. The deintegration time bars are simplified, but are based on the more detailed analyses performed for buildup operations. The deintegration activities are performed at KSC and are defined to terminate with configuration of all Spacelab racks and floors in a configuration ready for initiation of staging for the next payload.

Life Sciences Payload Ground Processing Cycles

In order to define the total involvement time of the Spacelab flight hardware and the manpower support requirement during non-level IV integration activities, time-flow diagrams for the entire cycle of ground operations were prepared. These diagrams are initiated at staging (at KSC) and encompass level IV activities, applicable KSC-STS operations, a reference mission of seven (7) calendar days, post-flight STS operations, and finally level IV deintegration.

Flows for distributed site operations are shown in Figure 3-56. The number in the blocks refer to the functional activities defined in Section 2. The sixteen day duration for the experiment installation and verification activity (S&G) reflects the maximum time required at a distributed site. The only difference between the two distributed site options is the combined payload checkout activity in an off-line area at KSC in the A-3 option.

Lead center cycle summations are presented in Figure 3-57. Options B-1 and B-3 are comparable to the A-1 and A-3 options. A minor difference exists in functional activities 5 and 6 because of the sharing/scheduling of GSE. The difference between the B-4 and B-5 options can be attributed to the addition payload disassembly (Block 9) and reassembly (Block 10) of the B-5 option.

KSC ground processing cycle summations are presented in Figure 3-58. The only difference between comparable lead center and KSC options is the required transportation times.

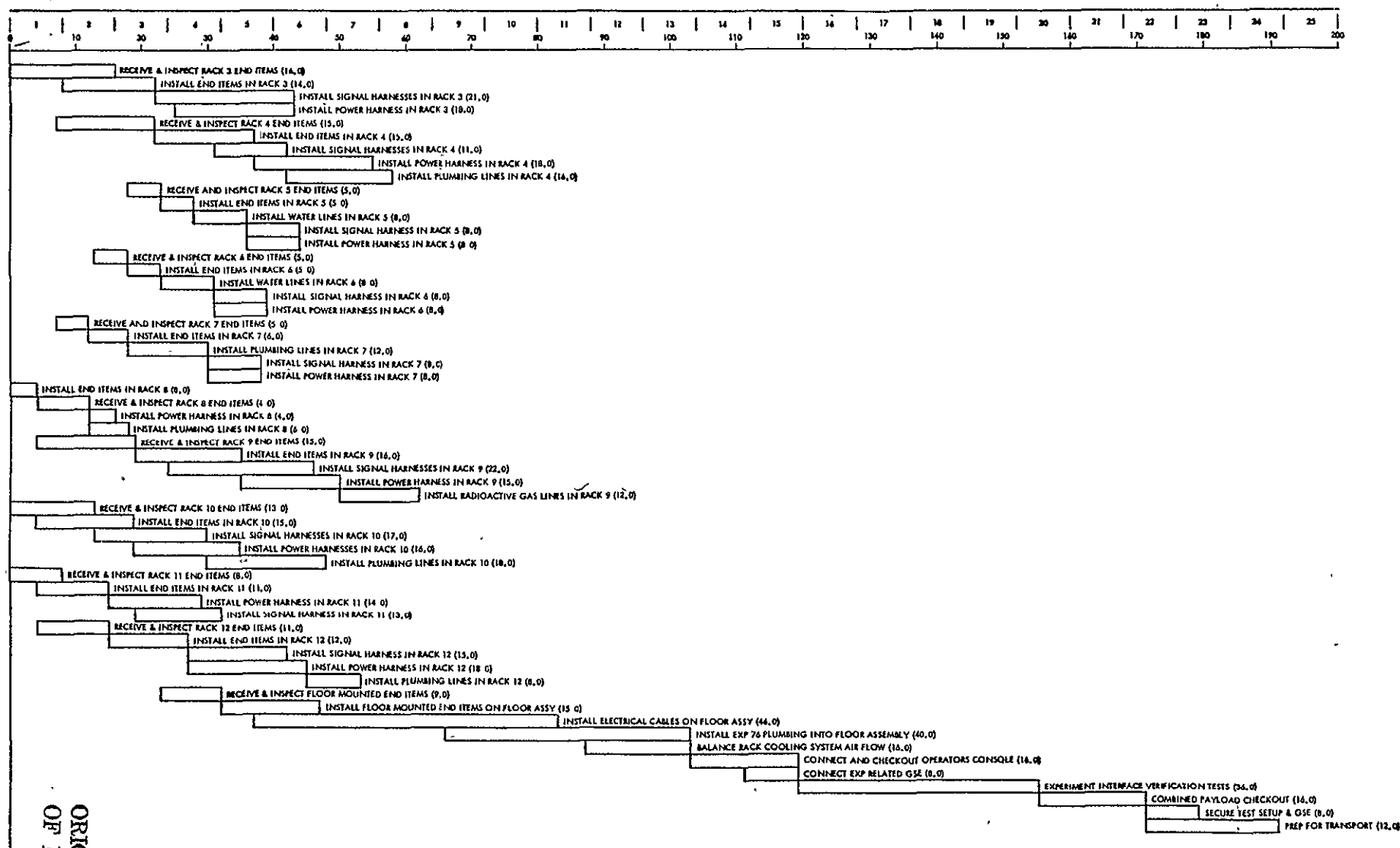


Figure 3-54. Life Sciences Combined Payload Integration Sequence

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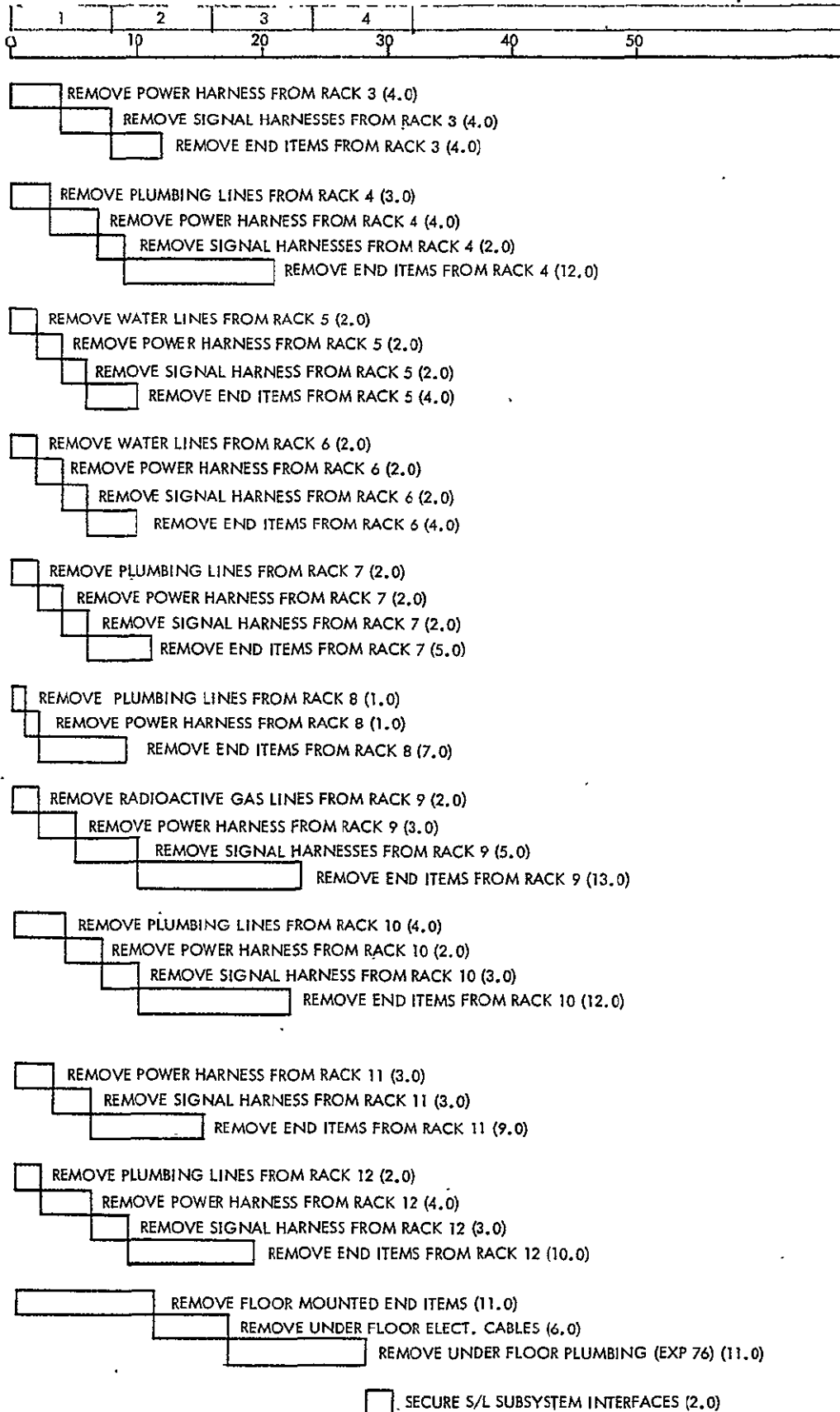


Figure 3-55. Life Sciences Deintegration

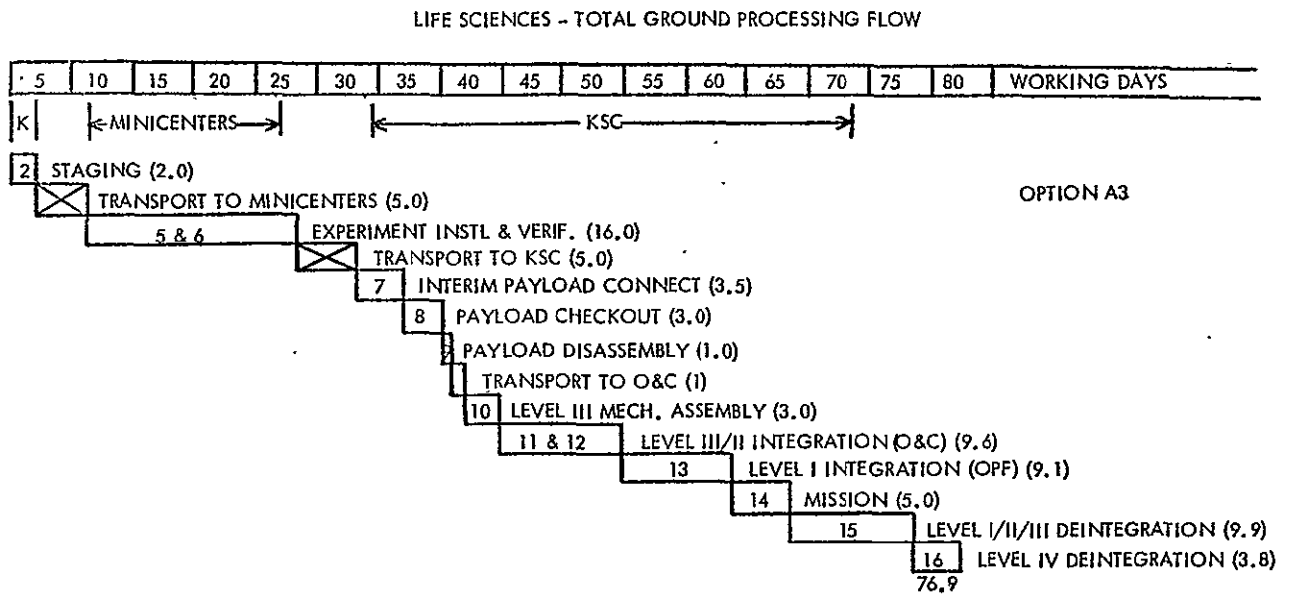
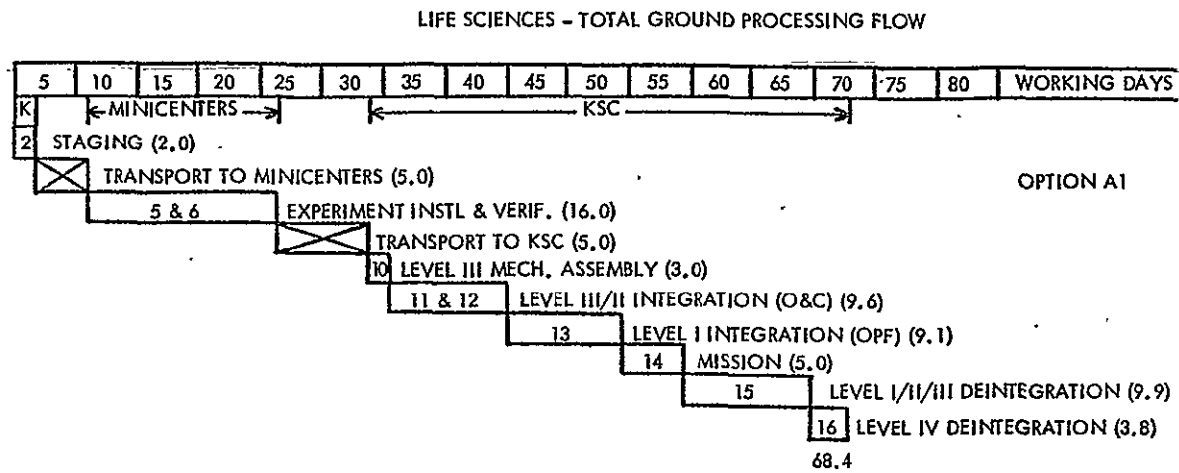


Figure 3-56. Life Sciences Distributed Site
Ground Processing Cycles

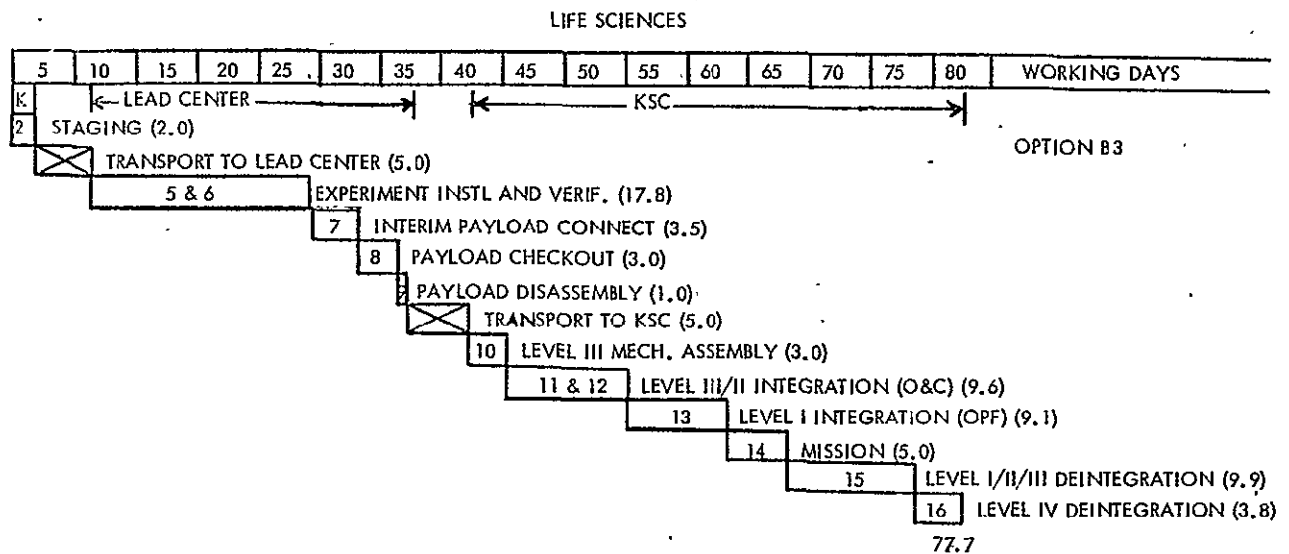
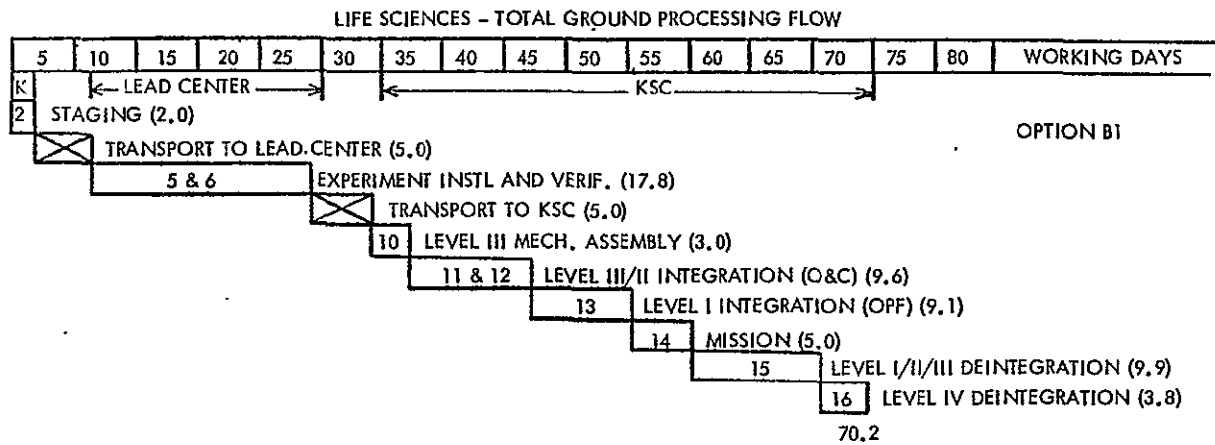


Figure 3-57. Life Sciences Payload Lead Center Life Cycle B-1, B-3, B-4 & B-5

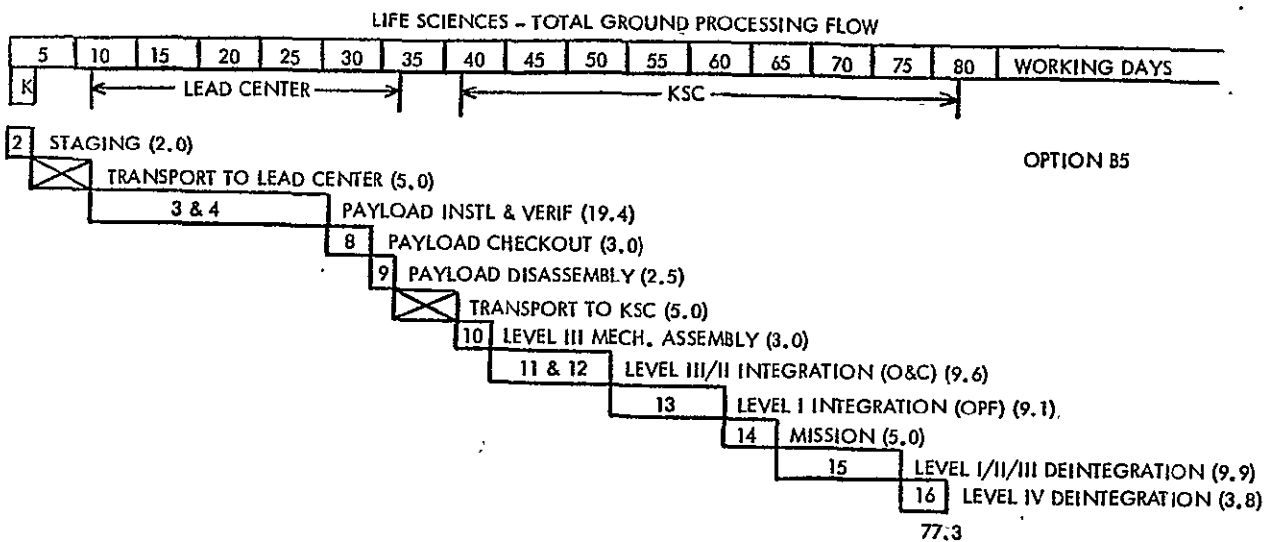
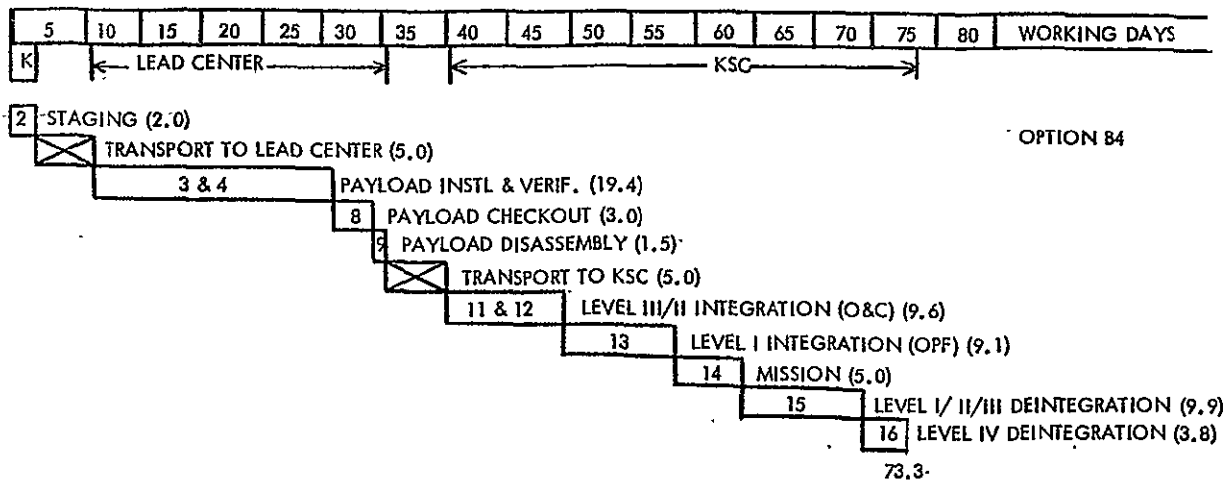


Figure 3-57. Life Sciences Payload Lead Center Life Cycle Flow B-1, B-3, B-4 & B-5 (Cont'd)

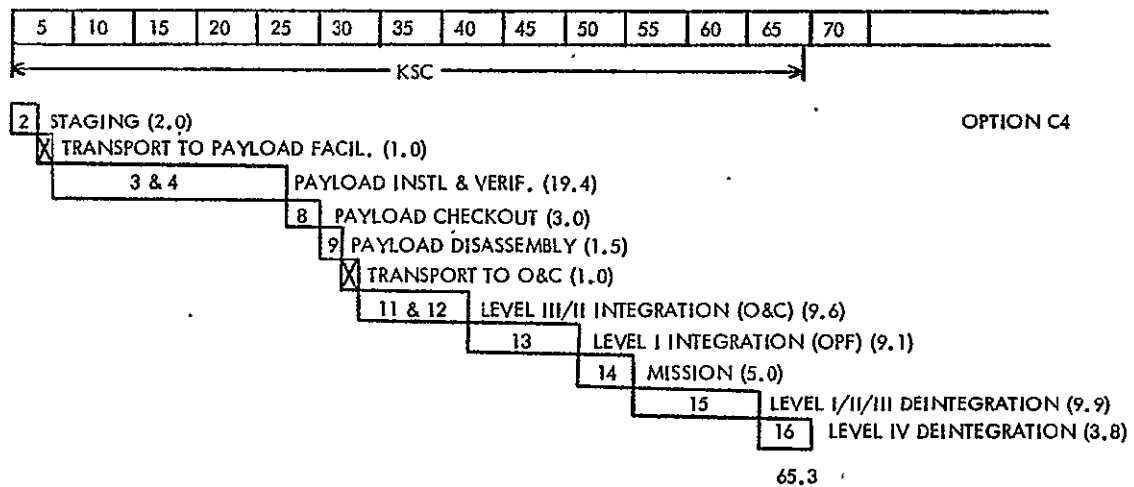
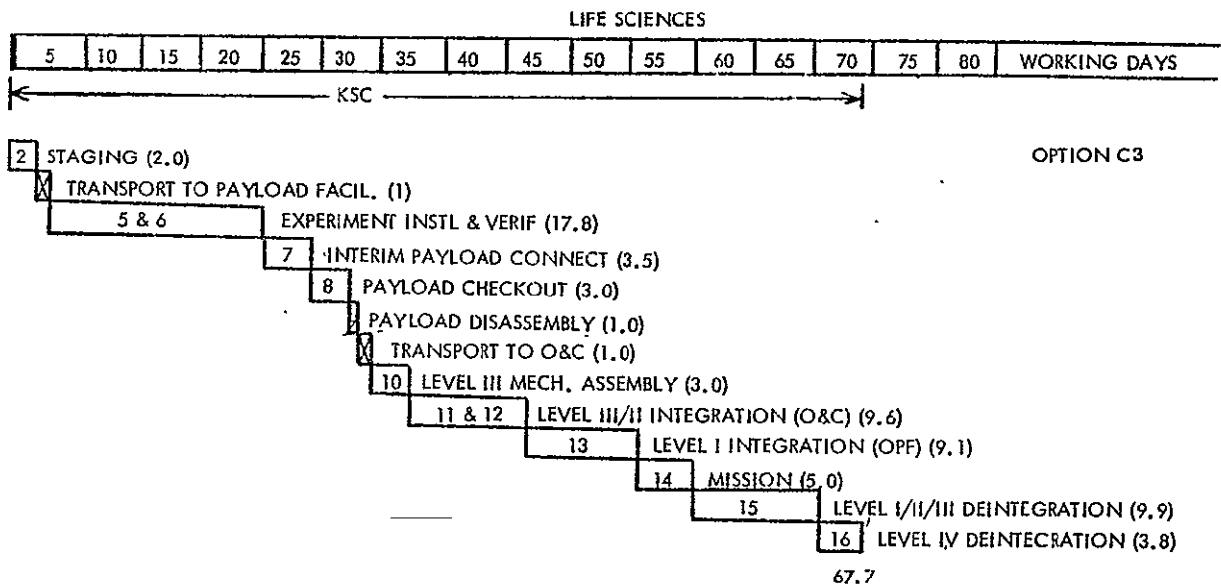
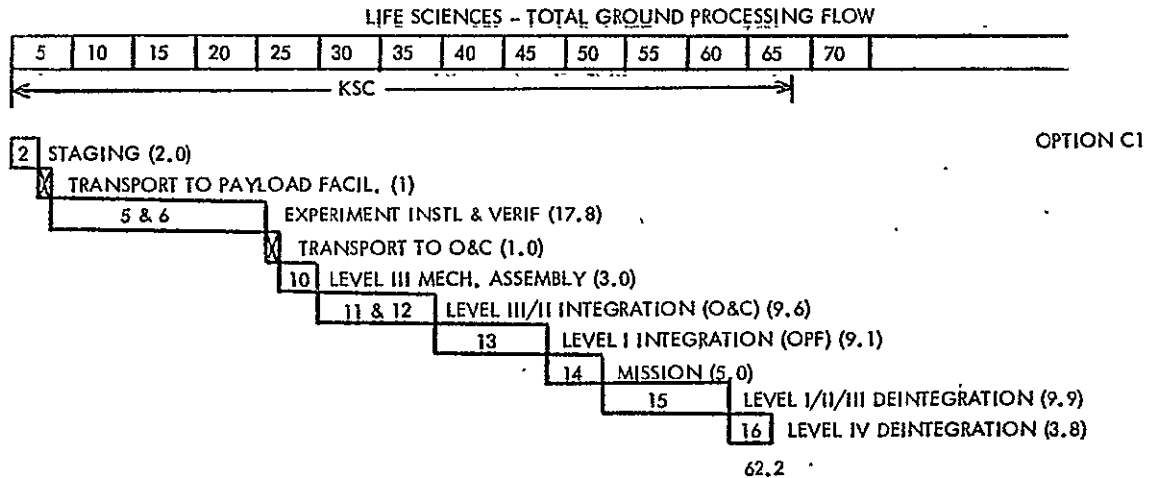


Figure 3-58. Life Sciences Payload Total Life Cycle Flow -
Lead Center Concept (KSC), C-1 and C-3 and C-4



ATL PAYLOAD INSTALLATION & TEST REQUIREMENTS

The ATL payload consists of short module rack mounted equipment, pallet mounted equipment, cradle mounted equipment, and Orbiter AFD equipment. The general configuration of the payload is shown in Figure 3-59.

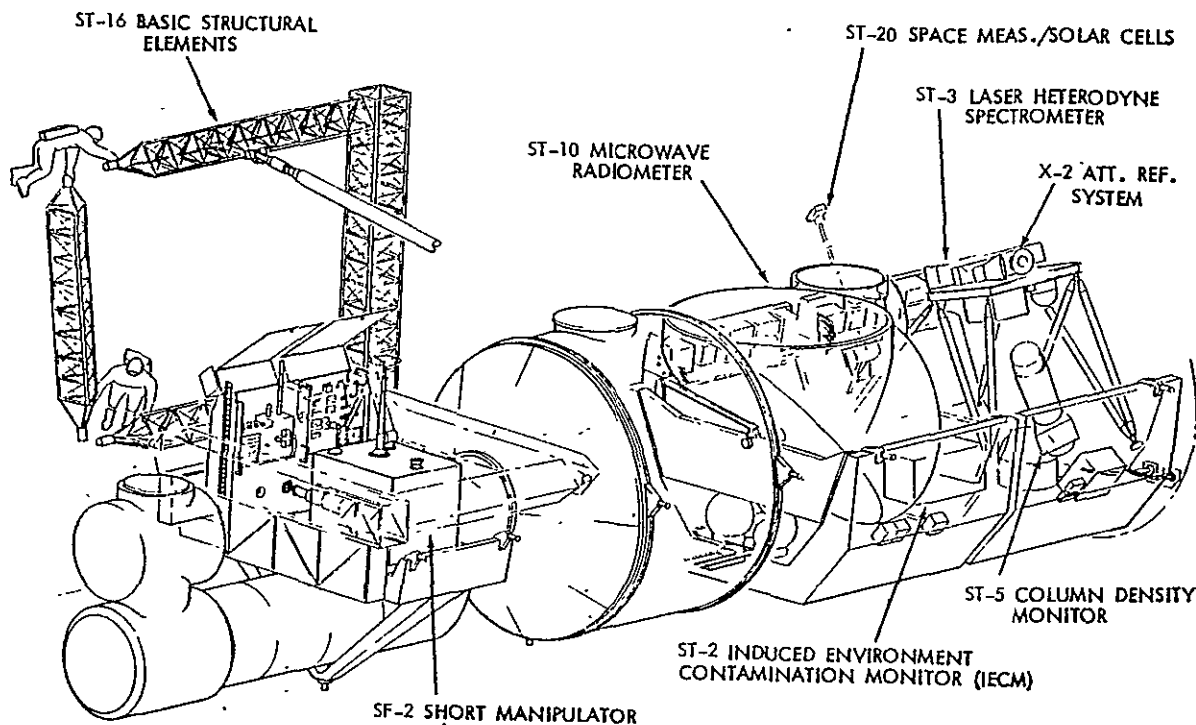


Figure 3-59. General Arrangement - ATL Payload

Figure 3-59 illustrates the overall arrangement of the ATL payload. As noted, this payload consists of a short Spacelab module and two Spacelab and 12 experiments. Two of these experiments, Basic Structural Elements (ST-16) and Short Manipulator (SF-2) are mounted on a special support structure forward of the module over the crew tunnel. Five experiments -- Microwave Radiometer (ST-10), Space Measurement/Solar Cells (ST-20), Laser Spectrometer (ST-3), Column Density Monitor (ST-5), and Induced Environment Contamination Monitor (ST-2) -- are shown mounted on the two pallets. The Attitude Reference System (X-2), which supports ST-3, is also shown.

The phantom lines forward of the module and shown surrounding SF-2 represent the fully assembled ST-16 structure as it is returned to earth for laboratory inspection.



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The Spacelab module arrangement of the ATL payload, including the rack mounted equipment, is detailed in Figure 3-60.

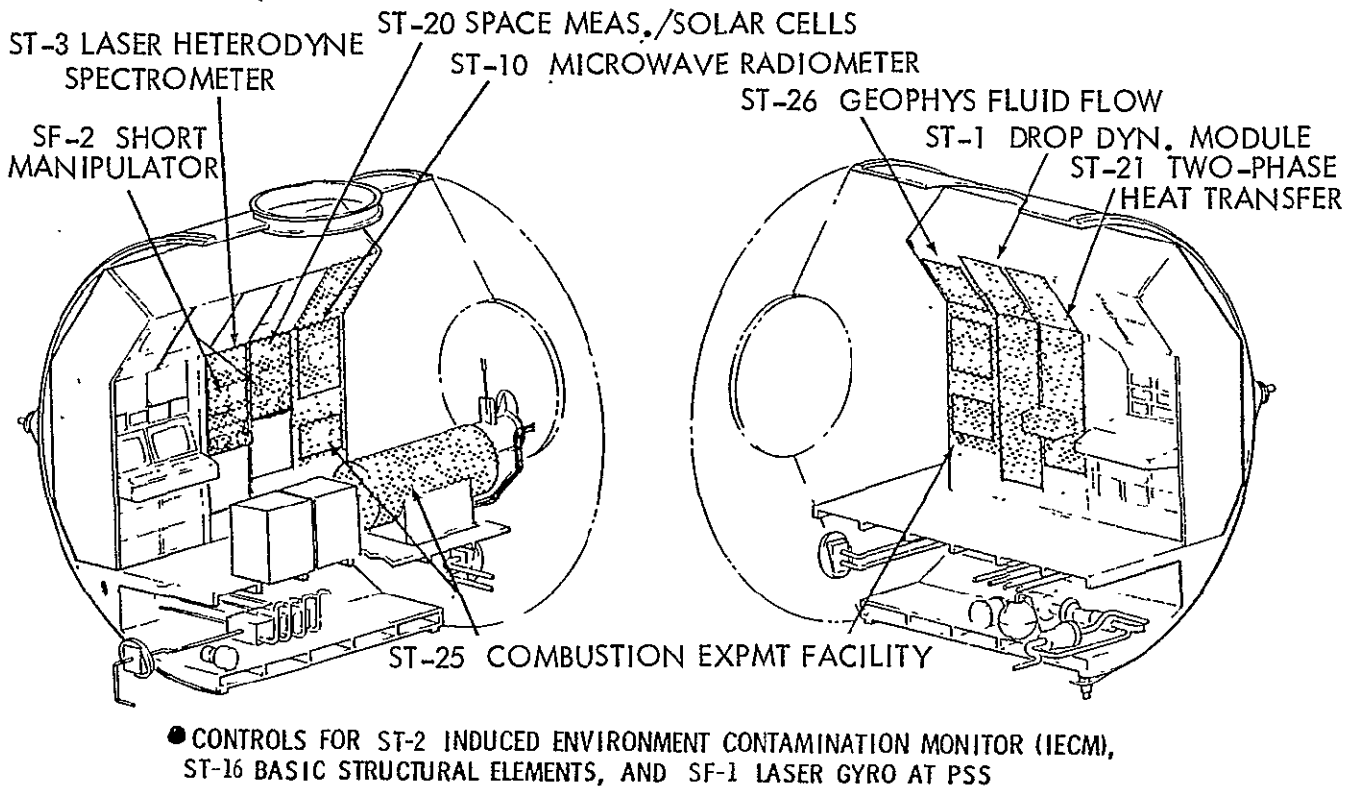


Figure 3-60. Spacelab Module Arrangement - ATL Payload

This figure illustrates the arrangement of the experiments in the Spacelab module as well as the controls/displays for those mounted externally (shown in the previous figure). In the experiment racks, on the right-hand side of the module, are shown the controls/displays for SF-2, ST-3, ST-20, and ST-10, and the Laser Beam portion of ST-25. A video recorder is also located in the upper portion of the forward experiment rack.

The left-hand experiment racks contain ST-26 (Geophysical Fluid Flow), ST-1 (Drop Dynamics), and ST-21 (Two-Phase Heat Transfer) experiments. Also on this side are the photomultiplier tubes of ST-25. The major portion of ST-25 (Combustion Facility) is mounted on the Spacelab module floor. The chamber is vented to space by the Spacelab high-vacuum vent facility, mounted on the aft cone cover plate. Also shown are the chamber's oxygen, nitrogen, and methane gas fill lines which connect to the containers mounted on the first pallet.

Film and tapes are stored in the containers immediately forward of ST-25 combustion chamber on the module floor, in the storage compartments over the module's workbench and in the right-hand experiment racks.



The ATL Orbiter Aft Flight Deck arrangement of controls and displays and the installation of the Laser Gyro experiments are illustrated in Figure 3-61.

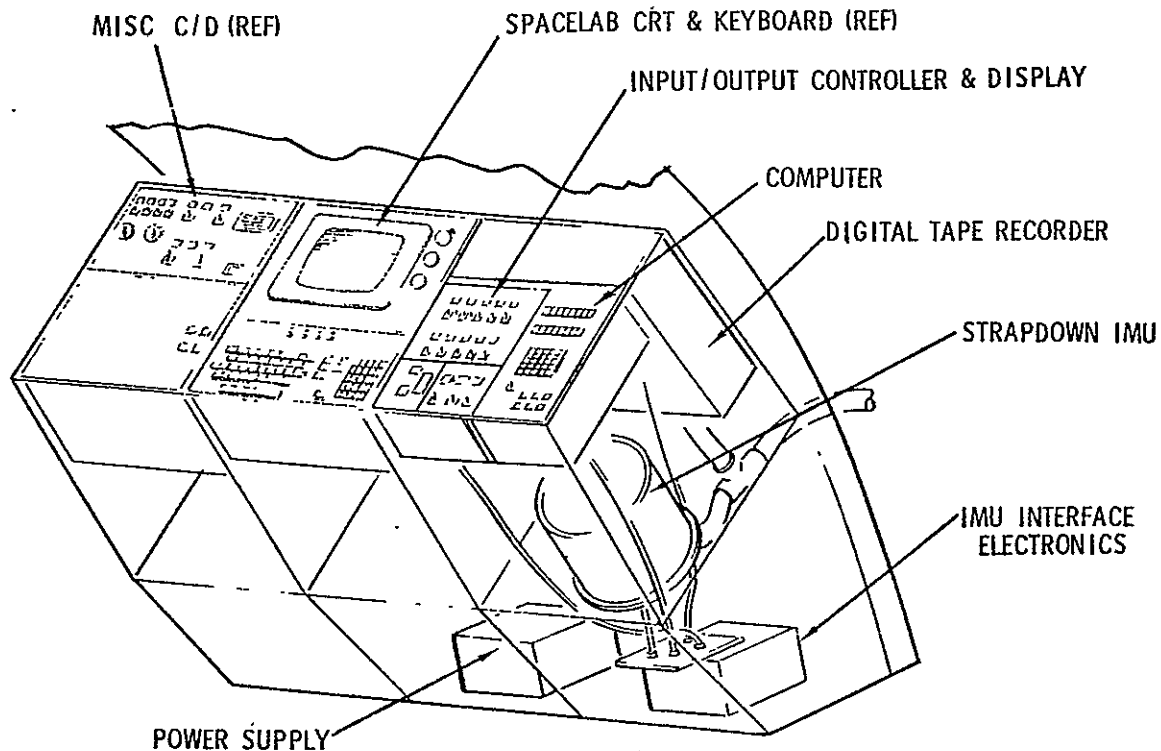


Figure 3-61. Orbiter Aft Flight Deck Arrangement -
ATL Payload

The installation of SF-1 (Laser Gyro) on the Orbiter aft flight deck at the payload specialist station (PSS) is shown on this figure. As this experiment is intended to operate throughout the entire mission, at times when the Spacelab is deactivated, its installation at the PSS was necessary. The input/output controller, display, and tape recorder are mounted on the upper face of the PSS module, accessible to the crew, while the strap-down IMU, power supply, and interface electronics are mounted inside the module.

Spacelab CRT, keyboard, and miscellaneous recorder and video camera controls are also shown on this figure. The miscellaneous controls associated with the other experiments (ST-2 and ST-16) are also provided.

Applicable Ground Processing Options

All but three of the ground processing options defined in Section 2 are applicable to the ATL payload. The three exceptions are A-2, B-2, and C-2. These three options are



not applicable because level III assembly is required during KSC-STS operations, if multiple/decoupled experiment/integration operations are conducted. Racks must be assembled to floor segments and pallet segments must be assembled into pallet trains in the Level III assembly stand at KSC. This constitutes Block 10 activity during KSC operations. Ground processing requirements were developed for all of the remaining nine options.

Distributed site options A-1 and A-3 reflect level IV integration at geographically separated sites. Option A-3 incorporates an off-line combined payload checkout activity at KSC prior to installation of KSC-STS operations. Options B-1 and C-1, and B-3 and C-3 are comparable to the A-1 and A-3 options respectively except that the integration occurs at one geographical location - either at a lead center (for the "B" options) or KSC (for the "C" options). Combined payload buildup options B-4, B-5, and C-4 are also applicable. The only difference in the integration activities of the B-4 and C-4 options is the location. Minimization of GSE requirements and maximization of personnel use is reflected in this option. The B-5 option is identical to the B-4 option except for the preparation for shipment activities. In order to limit the width of the over-the-road load to less than twelve (12) feet, the two pallet train is disassembled at the lead center and re-assembled in the level III stand at KSC.

Installation/Integration Constraints

The ATL payload experiment complement and configuration was assessed to determine viable subdivisions of integration activities. Four Spacelab racks and two pallet segments are the primary Spacelab mounting elements. Theoretically, six decoupled integration activities could be synthesized. However, neither pallet segment can be decoupled from rack mounted equipment and still achieve effective/efficient level IV integration. Also, the combustion facility experiment requires two facing racks and an assembly mounted on the interconnecting floor segment. Thus, rack-floor and rack-pallet segment combinations were determined to be the only practical combinations for decoupled level IV integration activities.

The selected combinations of experiments and Spacelab mounting elements for decoupled integration activities are listed in Table 3-14. Each experiment can be totally integrated and verified at a site. In no case are end items of an experiment required at more than one site.



Table 3-14. Mini-Center Experiment and Spacelab Hardware Distribution

	Expt. No.	Title
Mini-Center No. 1	ST-10 ST-25 ST-26	Spacelab Rack No. 5 Spacelab Rack No. 6 Experiment Floor Segment Pallet No. 1 Microwave Radiometer Measurements Combustion Facility Geophysical Fluid Flow
Mini-Center No. 2	ST-1 ST-21	Spacelab Rack No. 3 Drop Dynamics Module Two-Phase Heat Transfer Facility
Mini-Center No. 3	SF-2 ST-2 ST-3 ST-5 ST-16b ST-20 X-2	Spacelab Rack No. 4 Pallet No. 2 Forward Support Structure Space Teleoperator Demonstration Unit External Contamination Monitoring Tunable Lasers For Resolution Atmospheric Constituents and Pollutants Adv. Tech. Radiometer/Column Density Basic Structural Elements (Erectable) Space Calibration of Solar Cells Precision Attitude Reference Determination System

Ground Processing Equipment Requirements

Level IV integration activities are initiated upon receipt of all equipment necessary for installation and verification. Equipment considered essential includes experiment equipment, Spacelab interfacing equipment, Spacelab oriented GSE, and experiment unique special test equipment.

Experiment Equipment

A compilation of experiment equipment and interconnection equipment is presented in Table 3-15. The table identifies those end items that will be installed at each distributed site. All of the listed equipment is required at a centralized site. The FSS equipment which cannot be installed until level I integration was included in the inventory of mini-site 3 equipment because of the associated controls that will be mounted in rack No. 4. The AFD experiment, X-2, was arbitrarily included in the inventory of mini-site 3.



Table 3-15. Experiment End Item Equipment

ITEM DESIGNATION	DISTRIBUTED (MINI) CENTERS		
	SITE #1	SITE #2	SITE #3
RACK INSTALLED EXPERIMENT END ITEMS	1 (SET)	1 (SET)	1 (SET)
PALLET INSTALLED END ITEMS	1 (SET)	1 (SET)	1 (SET)
RACK CABLE SETS	4	2	2
PALLET CABLE SETS	2	0	2
INTER-RACK CABLE SETS	4	0	0
FILM VAULTS	0	0	3
OPTICAL BENCH TRUNNION	0	1	0
ORBITER INSTALLATION (AFD) (LEVEL II)	0	0	0

Spacelab Flight Hardware

The required complement of Spacelab provided flight hardware for the ATL payload is listed in Table 3-16. Note the transition cables across the first pallet of the two pallet train (for functions on the second pallet) are also identified as Spacelab provided.

Table 3-16. Spacelab Unique Flight Hardware

ITEM DESIGNATION	DISTRIBUTED (MINI) CENTERS		
	SITE #1	SITE #2	SITE #3
PALLETS	1	0	1
RACKS, SPACELAB, DOUBLE	0	1	1
RACKS, SPACELAB, SINGLE	2	0	0
FLOOR SEGMENT (RACK), DOUBLE	1	0	0
COLD PLATE ASSEMBLY	7	0	0
EXPERIMENT POWER DISTRIBUTION BOX (EPDB)	1	0	1
REMOTE ACCESS UNITS (RAU'S)	1	0	1
POWER HARNESS, PALLET	1	0	1
SIGNAL HARNESS, PALLET	1	0	1
UTILITY BRIDGE, CONN. BRACKET, FEEDTHRU	1	0	1



Ground Support Equipment

Table 3-17 provides a list of the required Spacelab related GSE. Descriptions of each item of GSE are presented in Appendix E. Both distributed site and centralized site requirements are identified. A significant reduction in GSE requirements for the centralized site approach can be noted.

Table 3-17. Ground Support Equipment

ITEM DESIGNATION		LEAD CENTER REQMTS.	DISTRIBUTED (MINI) CENTERS		
			SITE #1	SITE #2	SITE #3
DOUBLE RACK HANDLING KIT	613050	1	0	1	1
VERTICAL SLING KIT	612006A	1	1	0	1
FEED THRU-PROT. COVERS	612008	1	1	0	1
PALLET SEG. FLOOR COVERS	612010	2	1	0	1
PALLET SEGMENT SUPPORT	612013	1	1	0	1
RACK/FLOOR SHIPPING COVER	612047	1	1	0	0
RACK/FLOOR TRANSPORT PLATFORM	612048	1	1	0	0
RACK/FLOOR SUPPORT BRACES	612049	1	1	0	0
PALLET COVER	612059	2	1	0	1
PALLET PLATFORM	612060	2	1	0	1
DESICCANT CANISTER LARGE	612067	1	1	0	1
DESICCANT CANISTER MEDIUM	612068	1	1	1	1
ACTIVE ENVIRONMENT CART	612071A	2	1	0	1
ROAD TIEDOWN KIT	612106	1	1	0	1
HORIZONTAL SLING KIT	612110	1	1	0	1
TRUNNION HANDLING FITTINGS	612113	4	4	0	4
REFRIGERATION UNIT	612115	1	1	0	0
RACK COOLING UNIT	612XXX	1	1	1	1
CLEANING KIT	612114	1	1	1	1
DESICCANT DRYING OVEN	614002	1	1	0	1
GROUNDING/BONDING TESTER	613039	1	1	1	1
PORTABLE LEAK DETECTOR	612080	1	1	1	1
FREON SERVICER	612084	1	1	0	0
FREON LEAK DETECTOR	612086	1	1	0	0
OPTICAL ALIGNMENT KIT	612040	1	1	0	1
TRANSPORT INSTRUMENTATION	614XXX	1	1	0	1
OPERATOR'S CONSOLE	612XXX	1	1	0	0

Special Test Equipment

In addition to the Spacelab related GSE, experiment unique GSE is also required. These items are identified in Table 3-18. The items are considered to be provided by the experimenter and are only for handling, installation, and verification of interfaces established during level IV integration.



Table 3-18. Special Test Equipment

ITEM DESIGNATION	LEAD CENTER REQMTS.	DISTRIBUTED (MINI) CENTERS		
		SITE #1	SITE #2	SITE #3
CABLE SETS & ADAPTERS ①	1	1	1	1
OPTICAL BENCH SUPPORT CART ①	1	0	0	1
INERT GAS CART ①	1	1	1	1
FSS HOLDING JIG & COVER ①	1	0	0	1
BROAD BAND ILLUMINATOR ①	1	1	0	0
ANTENNA SUPPORT CART ①	1	1	0	0
① EXPERIMENTER GSE - NOT PRORATED				

Installation and Test Procedures

The basic tasks of installation and test are essentially the same regardless of the processing option used. Tasks required at each mini-center may be conducted serially or in parallel to the other mini-centers which will vary GSE, Manpower, and serial processing times. But the basic requirements remain the same. Thus, generic installation and test requirements were developed for the ATL payload that formed the basis for tailoring the activities to the particular sequence of activities of a processing option.

Assembly Procedures

A pictorial presentation of the installation activities of level IV integration is shown in Figure 3-62. The activities depicted in this figure provided the basis for development of the step-by-step sequence of activities. Also, the scenario was used as a check/balance that all required GSE was identified.

Test Procedures

The design configuration of the ATL payload/experiments requires a significant man-machine interface. Manual activation, control, and monitoring of the experiments is inherent in the design. Also, each experiment consists of numerous end items that are interconnected and interact with each other. Therefore, interface verification for this payload is extensive.

Verification test requirements were established for each experiment to establish the integrity of the installed configuration. It was assumed that all equipment was operational and within performance/specification limits. Therefore, the tests were prescribed only to verify proper response to a command. Acceptable responses included light indicators, meter readings, and CRT waveform, and status lists. Use of the PCM data stream via an interfacing RAU and CDMS simulator was included. Table 3-19 consists of a synopsis of the verification tests required for each experiment of the ATL payload after installation in the flight configuration. These test requirements were the basis for time and manpower estimates in the development of the ground processing flows.



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Table 3-19. ATL Experiment Verification Tests

Mini-Center 1 Verification

ST-10

Verify:

Main power on indicator and status panel of C/D
Antenna assy electromagnetic latch disconnect
Antenna assy motion off drive motor activation
Scan motor power on at indicator of C/D
Position lock disconnect of C/D
Scan drive activation from antenna scan
Scan position read out
On L/S, C/X, and K bands
Aux. control unit power on at C/D indicator
In mode manual observe digital temp R.O. from freq. variation
In channels 1,2, & 3 observe effect of calib. controls on digital temp.
VR1 & VR2 at digital voltmeter
T₀, T_{A1}, T_{A2} at digital voltmeter
Change in digital voltmeter from temp. set variation
Repeat previous five steps in mode auto sweep

ST-26

Verify:

System control power on
Use waveform record and CRT at signal amplifiers of tape recorder
to verify:
Modes in calibrate and operate test controls, set points, and sphere
conditions for experiments 1-10
Experiment number
System status
Test status
Tape recorder power on
Tape recorder operations

ST-25

Verify:

Main power on at indicator of C/D
System status at light panel
Chamber combust test position and pressure in positions 1,2, & 3
note changes in pressure R.O. at digital display



Table 3-19. ATL Experiment Verification Tests (Cont'd)

ST-25 (Cont'd)

Chamber combust in test position and temperature in positions 1, 2, & 3 note changes in temperature R.O. at digital display
Chamber combustion using simulated signal at pressure and temperature position
Vent open and close at indicator
Purge monitor using simulated signals
Spark igniter circuit using simulated signals
Test control power on and start
Droplet test power on
Syringe position in forward & reverse on digital display
Electrostatic field on
Drop deploy on
Limit test power on
Limit test inertial part deploy
Particle cloud test power on
Fuel particle deploy
Vibrator on
Liquid pool test power on
Pan fill on
Carbon test power on
Spectrometer on
Scan rate in fast, med, and low
Position rate in fast, med, and low
Temperature change in test and calibrate
Camera power on
Shutter operation in auto and fast forward modes
Frame rate selection (use film lead)
Gas mix fill power on
Regulator controls (3) off digital R.O.
Vent open and close
Combustion chamber on
Test chamber on
Pre mix valves (3) open and close
Oreface-tank switch (operation of valves)
Photomultiplier power on (1 and 2)
Sensitivity adjust 1 and 2 at digital R.O. using Output Selector and sensitivity select.
Data handling power and sequencer selection
Leak test plumbing



Table 3-19. ATL Experiment Verification Tests (Cont'd)

Mini-Center 2 Verifications

ST-1

Verify:

Verify at panel of power conditioning equipment, 28 VDC output.

ST-21

Verify:

Main power on at C/D indicator and system status
Pressurization ethanol valve open at C/D indicator
Pressurization methanol valve open at C/D indicator
Pressurization water valve open at C/D indicator
Boiler inlet ethanol valve open at C/D indicator
Boiler inlet methanol valve open at C/D indicator
Boiler inlet water valve open at C/D indicator
Boiler vent valve open at C/D indicator
Receiver inlet valve open at C/D indicator
Receiver dump valve open at C/D indicator
Bulk power on at C/D indicator
Test power on at C/D indicator
Radiant power on at C/D indicator
Flow tube power on at C/D indicator
Source selector in BH through voltage & current range
Source selector in TH through voltage & current range
Source selector in RH through voltage & current range
Source selector in FTH through voltage & current range
Digital R.O. of temperature & pressure at source selector N₂ thru TH
Cine camera power on at camera and indicator
Lights on at light indicator
Shutter operation in auto and fast forward
Film remaining (use film lead)
Data handling power on
Sequence selector at C/D indicator 1 thru 5



Table 3-19. ATL Experiment Verification Tests (Cont'd)

Mini-Center 3 Verification

SF-2

Verify:

- Main power on at indicator of C/D
- Cradle latch open at indicator of C/D
- Manipulator power in auto and manual positions on C/D
- Manipulator arm in deploy/retract to detent positions on indicators on C/D and by arm observation
- Lamp in test and status at indicator of C/D
- End effector in closed, hold, and open position on indicators on C/D and by observation
- Translation ratio readouts in high, medium and low on C/D and by observation
- Force readouts using simulated signals to manipulator
- Torque readouts using simulated signals to manipulator
- Manipulator brake positions 1, 2, 3, 4, 5 and 6 using light panel of C/D
- Heaters for arm on indicator of C/D
- Force and moment in X, Y and Z on meters of C/D
- Docking power on at indicator of C/D
- Docking probe deployment and retraction at C/D and observation
- Docking spin rate using simulated signal
- Docking motor power to detent at C/D indicator
- Docking latch open by observation and indicator of C/D
- Docking despin grip open using simulated signal
- Docking despin clutch using detent and indicator at C/D
- Power on at cameras A and B on C/D indicator
- Status at built in test of cameras A and B
- Zoom by observation and on display of C/D cameras A and B
- Positioning in deploy/retract/auto track/indicators and manual track by on C/D
- Pointing positions in up/down and L/R by observation
- Tilt position up/down by observation
- Task board power on by indicator on C/D
- Task board test on by indicator on C/D
- Status of task board on built-in test
- Voltages on task board on indicator of C/D
- Hand controller rotational control by observation
- Hand controller translation control by observation
- Video recorder power on and observation using playback and eraser.



Table 3-19. ATL Experiment Verification Tests (Cont'd)

ST-2

Verify:

Verify power to integrated environmental contamination monitor (OEM and AAM) at unit.

ST-3

Verify:

Main power on at C/D indicator
Refrigerator power on at C/D indicator
Detector power on at C/D indicator
Experiment power on at C/D indicator
Signal processor on at C/D indicator
Programmed power on at C/D indicator
System status at light panel
Optical bench and base unlock at C/D indicator and by observation
Optical bench and base covers open at C/D indicator and by observation
Refrigerator unlock at C/D indicator
Refrigerator change in temperature at digital display
Detector cooler valve open at C/D indicator
Detector change in temperature at digital display
Black body power on at C/D indicator
Temperature indication at C/D indicator
Scan track controller for simulated coordinates, the computer performance in test, standby, and run for modes nadir, horizon, and offset 1 and 2.
Dual telescope in horizon, nadir, and blackbody by observing focal plane movement.
Scan mirror mode for standby and track at C/D indicator
Scan mirror position in azimuth and elevation for track using increase and decrease drives at digital display
Programmed power at 8 positions of laser diode at indicator of C/D
Programmed power at 8 positions of gas cell at indicator of C/D
CCTV camera on at C/D indicator
Auto lite, and gamma in three positions using video display
Zoom using video display and camera observation
Recorder power on at C/D indicator
Signals at amplifiers of signal processor
Inert gas leak test



Table 3-19. ATL Experiment Verification Tests (Cont'd)

ST-5

Verify:

- Drive motor operation of sun sensor forward to position 1
- Drive motor operation of sun sensor reverse to position 2
- Drive motor return to operational position
- Solar cell amplifier output
- Temperature sensor output at the primary
- Temperature sensor output at the detector array
- Temperature sensor output at the secondary
- Temperature sensor output at the electronics
- Temperature sensor output at the Cornell spectrometer
- Temperature sensor output at the filter spectrometer
- Internal pressure sensor output of radiometer
- Sun Sensor Electromagnetic latch current amplitude
- Sun Sensor Electromagnetic latch deoperate current
- Cover closed contact switch output
- Filter wheel electromagnetic lock output at disconnect
- Filter wheel drive motor at positions 1,2,3,4,5,6,7,8 and 9 output
- Filter wheel electromagnetic lock output
- Detector readout (w/o calibration) (36)
- Detector preamp readout (w/o calibration) (36)
- Internal calibration unit output
- Detector readout (w/calibration) (36)
- Detector preamp readout (w/calibration) (36)
- Chopper electromagnetic lock release
- Chopper motor operation (verify chopper movement) and lock
- Cornell spectrometer readout (w/o calibration) (100 pos.)
- Cornell spectrometer readout (w/calibration) (100 pos.)
- Filter spectrometer readout (w/o calibration) (100 pos.)
- Filter spectrometer readout (w/calibration) (100 pos.)
- Phase lock amplifier readout (9)
- Power conditioner output (64 lines)
- Primary mirror heater output
- Data interface buffer output
- Data interface amplifier output
- Data interface formater output
- Tape recorder input to audio amplifiers (sample only)
- Tape recorder tape advance
- Inert gas leak test

Table 3-19. ATL Experiment Verification Tests (Cont'd)

ST-16B

Verify:

Instrument element B power on at indicator

ST-20

Remove Solar Cell Test Plate cover and illuminate with a sun simulator or strong broadband light source.

Verify:

- Main power at indicator
- Voltage outputs of solar cells, channels 1-50
- Temperature of thermocouples, channels 1-10
- Boom extend until indicated
- Boom retract until indicated
- Boom return to launch position
- Sun sensor sun acquisition
- Track lock
- Track mode drive (automatic)
- Track mode X and -X
- Track mode Y and -Y
- Sun shade drive (automatic)

Replace Solar Cell Test Plate cover and remove sun simulator.

Verify:

- (at system status)
- Multiplexer function
- Processor formatting



Table 3-19. ATL Experiment Verification Tests (Cont'd)

X-2

Verify:

- Power to IEU at C/D indicator
- Gyro heaters on at C/D indicator
- Gyro heater temperature normal at C/D light panel
- Computer power at C/D indicator
- Gyro 1-4 in attitude and bias at C/D digital R.O.
- Gyro 1-4 disable at digital R.O.
- Gyro restart at digital display
- Star tracker 1 and 2 power on at C/D indicator
- Star tracker 1 and 2 track mode at C/D digital R.O.
- Dark sun sensor output at C/D indicator
- Power to sun shade drive motor

Although ATL experiments do interface/share common recording equipments (Table 3-20), there is no experiment unique applications program resident in the CDMS computer. Verification of operational CDMS/ATL experiment software is required but this software only pertains to RAU/experiment interfaces for command initiation and data transfer - not data formatting, manipulation, or reduction. Thus, a CDMS simulator will be required to interface with the RAU's associated with some of the ATL experiments.

Table 3-20. Shared Equipments (Experiment & End Item Illustrated)

Digital Recorder	Video Recorder
X-2 (E.I. 6) ST-10 (E.I. 13) ST-3 (E.I. 15) SF-2 (E.I. 12) ST-21 (E.I. 7) ST-25 (E.I. 11a) ST-16B (E.I. 8)	SF-2 (E.I. 11) ST-16B (E.I. 10)



Installation and Test Sequences (Waterfalls)

Level IV installation and test sequences were prepared for each mini center and lead center concept applicable to the ATL payload. Mini-center sequences are presented in Figures 3-63 to 3-65. Each flow was developed to reflect the minimum time required to complete the level IV activity.

Mini-Center No. 1

Items processed through mini-center 1 consists of Pallet 1, Spacelab racks 5 and 6, and the floor segment to support the combustion chamber of Exp. ST-25. The combustion chamber must be aligned with Exp. end items located in racks 5 and 6 prior to verification. Because of the size and location of the ST-10 antenna assembly, installation is deferred until all other Pallet #1 end items and harness and fluid lines are installed. See Figure 3-63.

Mini-Center No. 2

Rack 3, assembled at mini center 2, consists entirely of experiment ST-21 end items. It can be assembled and verified independently of other racks and pallets. If mini-centers were to be minimized, this activity could be combined with another mini center with minimum impact. However, it was considered separately to reflect a more representative ATL type of payload. See Figure 3-64.

Mini-Center No. 3

Rack 4 along with pallet 2, and the FSS, are mated with the appropriate end items at this mini center. Prior to verification, the rack, FSS and pallet 2 must be mated electrically. This is accomplished where possible with flight harnesses, but in most cases is done with GSE wiring. The inter-pallet harnesses which are installed in pallet 1 are simulated on pallet 2 by GSE cables. See Figure 3-65.

Centralized Site Sequences

Two centralized site sequences were developed. The first sequence (See Figure 3-66.) reflects the level IV integration activities associated with individual/decoupled experiment/mounting element integration. Applicable options are B-1, B-3, C-1 and C-3. In options B-1 and C-1 (shown in Figure 3-66), the level IV activity is completed upon completion of individual experiment/mounting element verification tests (comparable to the A-1 option). In the case of the B-3 and C-3 options (not shown), the additional combined payload checkout activity is applicable (comparable to the A-3 option).

DAYS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19											
HRS	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120	125	130	135	140	145	150

RECEIVE & INSPECT ST-25 END ITEMS & ASSOC. S/L EQUIPMENT (8)
 RECEIVE & INSPECT ST-10 END ITEMS & ASSOC. S/L EQUIPMENT (8)
 RECEIVE & INSPECT ST-26 END ITEMS & ASSOC. S/L EQUIPMENT (8)

INSTALL ST-25, EI 8 INTO RACK 5 (2)
 INSTALL ST-25, EI 11b INTO RACK 6 (2)
 INSTALL ST-25 EI's 9 & 10 INTO RACK 5 (2)
 INSTALL ST-25, EI 7 ON RACK 6 (1)
 INSTALL ST-25, EI 3 ON RACK 6 (1)
 INSTALL ST-25, EI 2 ON EI 1 (2)
 INSTALL ST-26, EI 1 ON RACK 5 (1)
 INSTALL ST-26, EI 2 ON RACK 5 (1)
 INSTALL ST-10, EI 14 ON RACK 6 (1)
 INSTALL RACKS 5 & 6 ON FLIGHT FLOOR (6)
 INSTALL ST-25, EI 1 ON FLOOR & ALIGN WITH EI 7 & 8 (4)
 INSTALL POWER HARNESS ON RACK 5 (12)
 INSTALL POWER HARNESS ON RACK 6 (12)
 INSTALL SIGNAL HARNESS ON RACK 5 (12)
 INSTALL SIGNAL HARNESS ON RACK 6 (12)

INSTALL ST-25, EI's 4 & 5 ON PALLLET (4)
 INSTALL ST-10, EI 8 ON COLD PLATE (4)
 INSTALL ST-10, EI 9 ON COLD PLATE (4)
 INSTALL ST-10, EI 11 ON COLD PLATE (4)
 INSTALL ST-10, EI 10 ON COLD PLATE (4)
 INSTALL ST-10, EI 12 ON COLD PLATE (4)
 INSTALL ST-10, EI 7 ON COLD PLATE (4)
 INSTALL ST-10, EI's 1 through 6 & 15 ON SUPPORT STRUCTURE & STORE (4)
 INSTALL FILL & VENT LINES FOR ST-25, EI 4 & TERMINATE AT UTILITY TRAY (4)
 INSTALL PALLET POWER HARNESS (36) (DO NOT CONNECT TO ANTENNA ASSY)
 INSTALL PALLET EXPERIMENT SIGNAL HARNESS (36) (DO NOT CONNECT TO ANTENNA ASSY)

CONNECT O₂, N₂ & CH₄ SUPPLY LINES BETWEEN ST-25, EI 1 & THE AFT END CONE SUPPLY LINE CONNECTOR (6)
 CONNECT VENT LINE BETWEEN ST-25, EI 1 & RACK VENT LINE CONNECTOR PANEL (6)
 CONNECT FREON SERVICER & REFRIGERATION UNIT TO THE S/S FREON LOOP Q/D's
 INSTALL ST-10 ANTENNA ASSEMBLY & CONNECT HARNESSES (4)
 INSTALL CABLING TO POWER & GSE (4)

VERIFY ST-10 (SEE TABLE 3-9) (8)
 VERIFY ST-25 (SEE TABLE 3-9) (8)
 VERIFY ST-26 (SEE TABLE 3-9) (4)
 DISCONNECT & STOW ST-25, EI 2 (1)
 DISCONNECT CABLING TO POWER & GSE, & AIR FLOW GSE (1)
 SECURE ALL EQUIPMENT FOR SHIPPING (8)

Figure 3-63 , ATL Mini-Center #1, Pallet 1, Racks 5 & 6.

3-134

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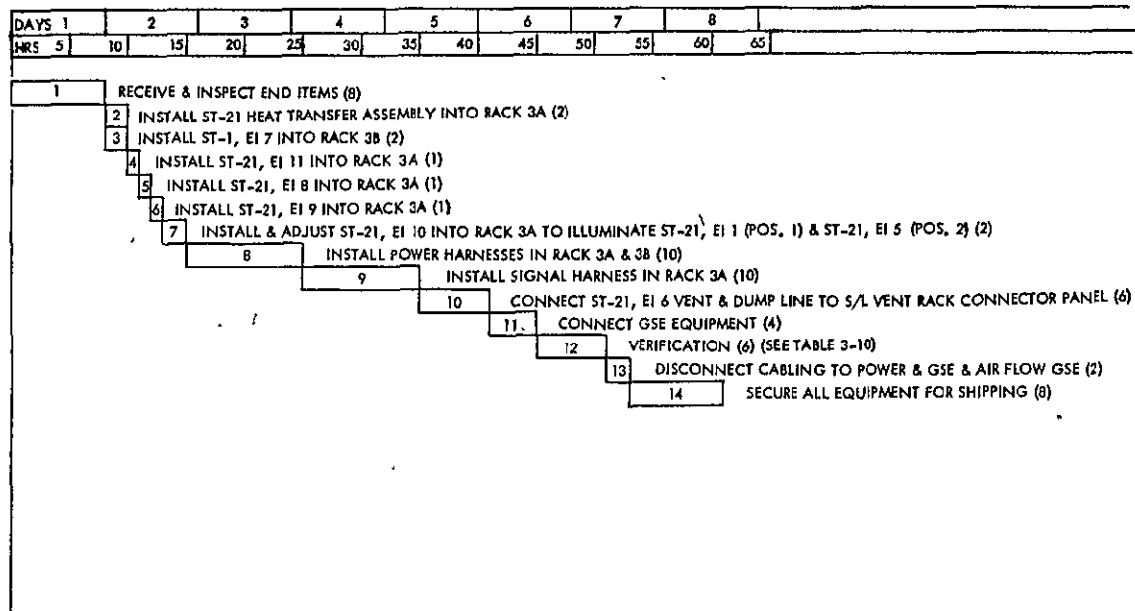


Figure 3-64 , ATL Mini-Center #2, Racks 3A & 3B

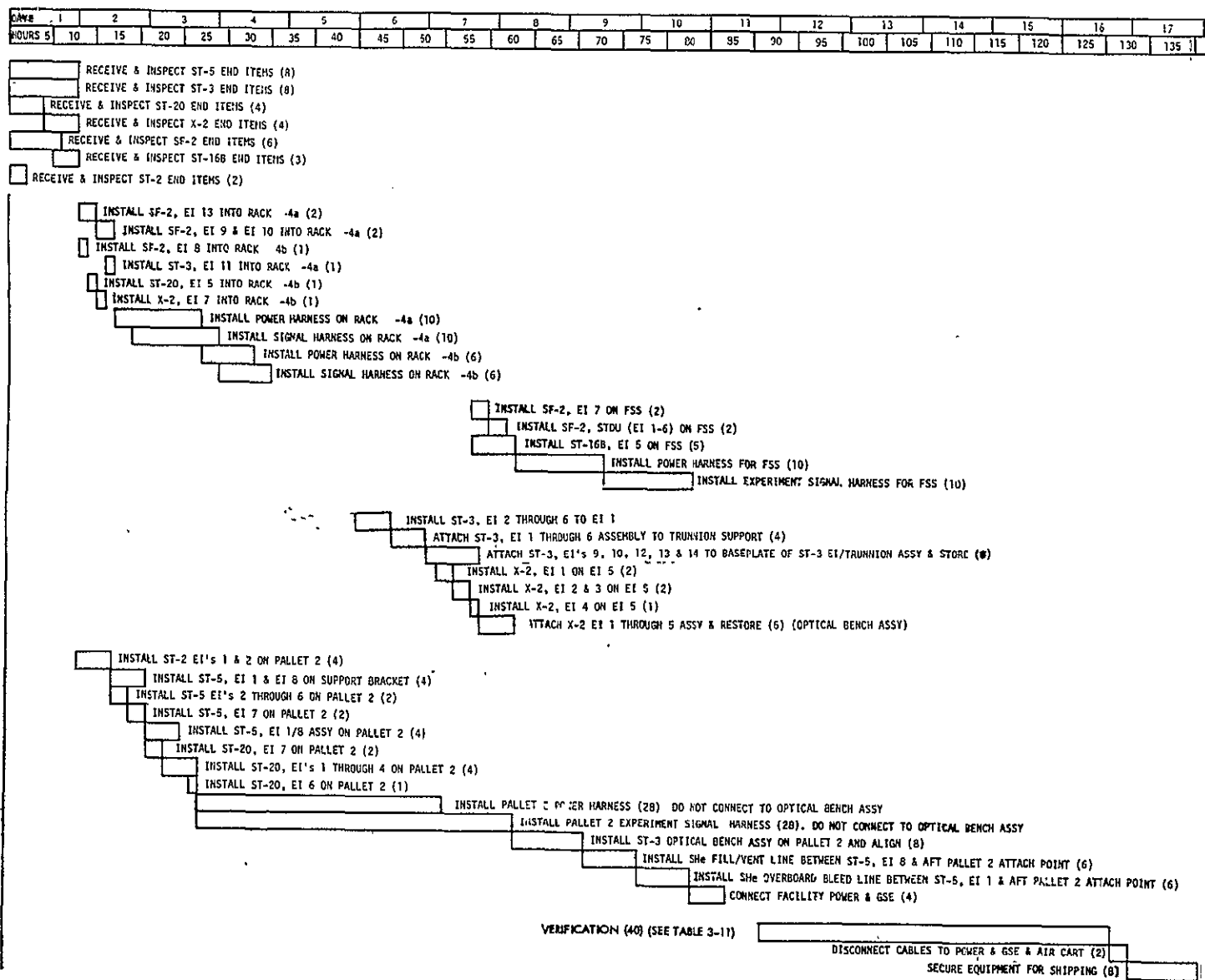


Figure 3-65 , ATL Mini-Center #3, Pallet 2, Racks 4A & 4B, & Special (SF-2 & ST16B)

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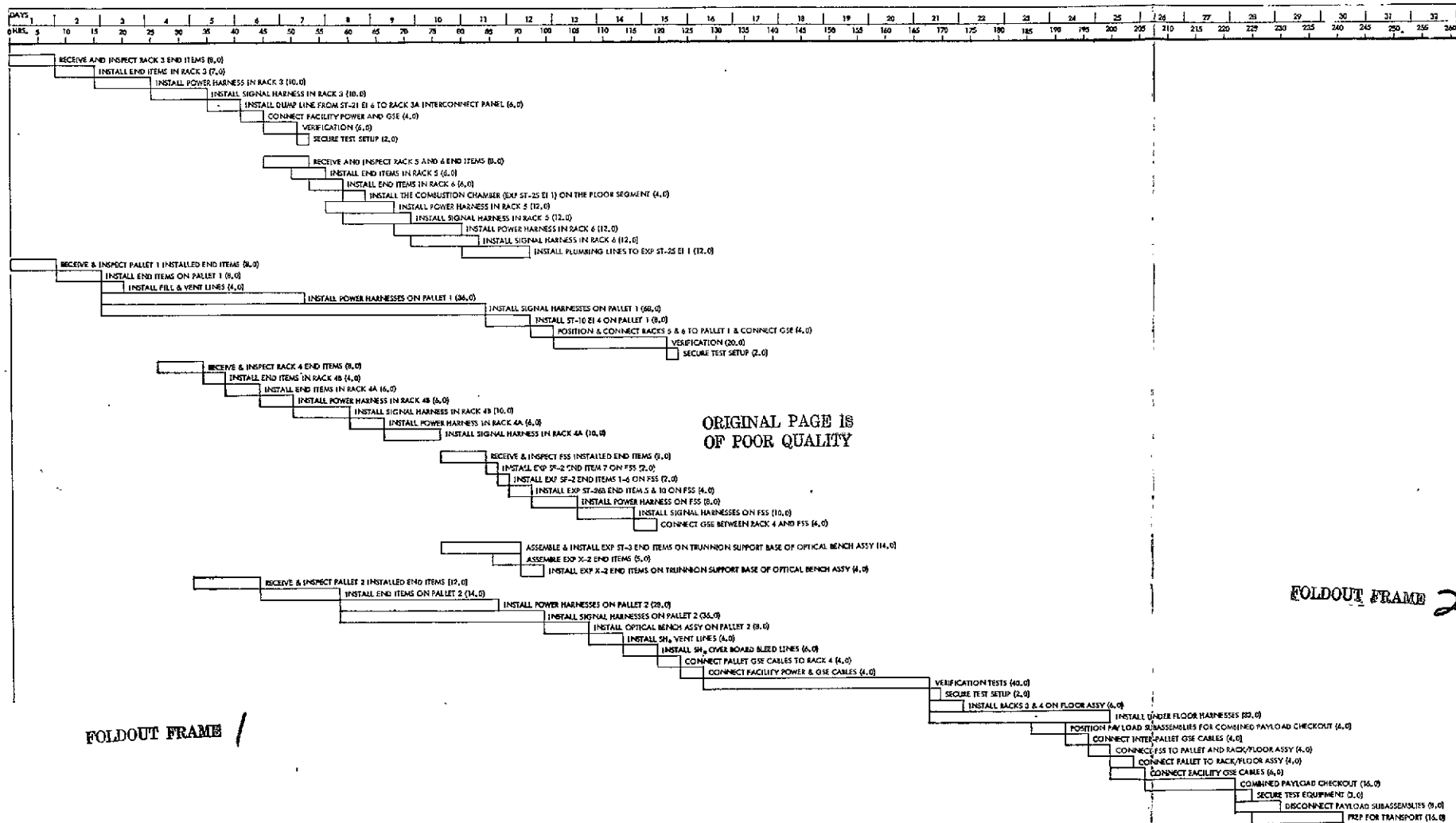


Figure 3-66, ATL Lead Center/KSC Processing Flow, Options B-1, B-3, C-1 & C-3



In all four of these options, individual racks and pallet segments are received at the integration site except racks 5 and 6 which are mounted to the floor segment. Regardless of which of the four options used the Spacelab mounting element (with the experiment equipment installed and verified) are returned to KSC for STS integration activities at the same level of assembly. That is, level III assembly in the O&C building is required.

The second detailed installation and test sequence (Figure 3-67) is applicable to the B-4, B-5 and C-4 options. In these options, the rack/floor assembly and pallet train are received at the level IV integration site. Other than alignment and grounding tests, all experiment equipment is installed in racks/on floors and pallets prior to verification testing.

The B-4 and C-4 activities are identical. However, a delta activity for the B-5 option is indicated in Figure 3-66. This activity pertains to the disassembly of the pallet train to facilitate over-the-road transportation with load widths less than twelve (12) feet.

Post Flight Experiment Deintegration Waterfall

Post flight deintegration of racks, floors, pallets and associated wiring and plumbing is shown in Figure 3-68. The deintegration time bars are simplified, but are based on the more detailed analysis performed for buildup operations. The deintegration activity occurs at KSC.

ATL Payload Ground Processing Cycles

In order to define total flight hardware involvement time, and support manpower requirements, flow diagrams were prepared to show the full cycle of installation and test activities which are required from start of staging to completion of post-flight deintegration. The diagrams illustrate the serial processing times required to accomplish the level IV effort associated with the preparations for and installation of experiment equipment, interface verification testing, and subsequent shipments. Applicable KSC-STS operations are included and reflect current time allocations. A reference mission time of seven (7) calendar days is also included.

Figure 3-69 summarizes the cycle for the applicable distributed options A-1 and A-3. The only difference is due to the off-line combined payload checkout activity (function blocks 7, 8 and 9) at KSC prior to KSC-STS operations. Applicable lead center cycles are presented in Figure 3-70. Cycles for KSC options are summarized in Figure 3-71. Transportation times are the only differences between comparable lead center and KSC options.

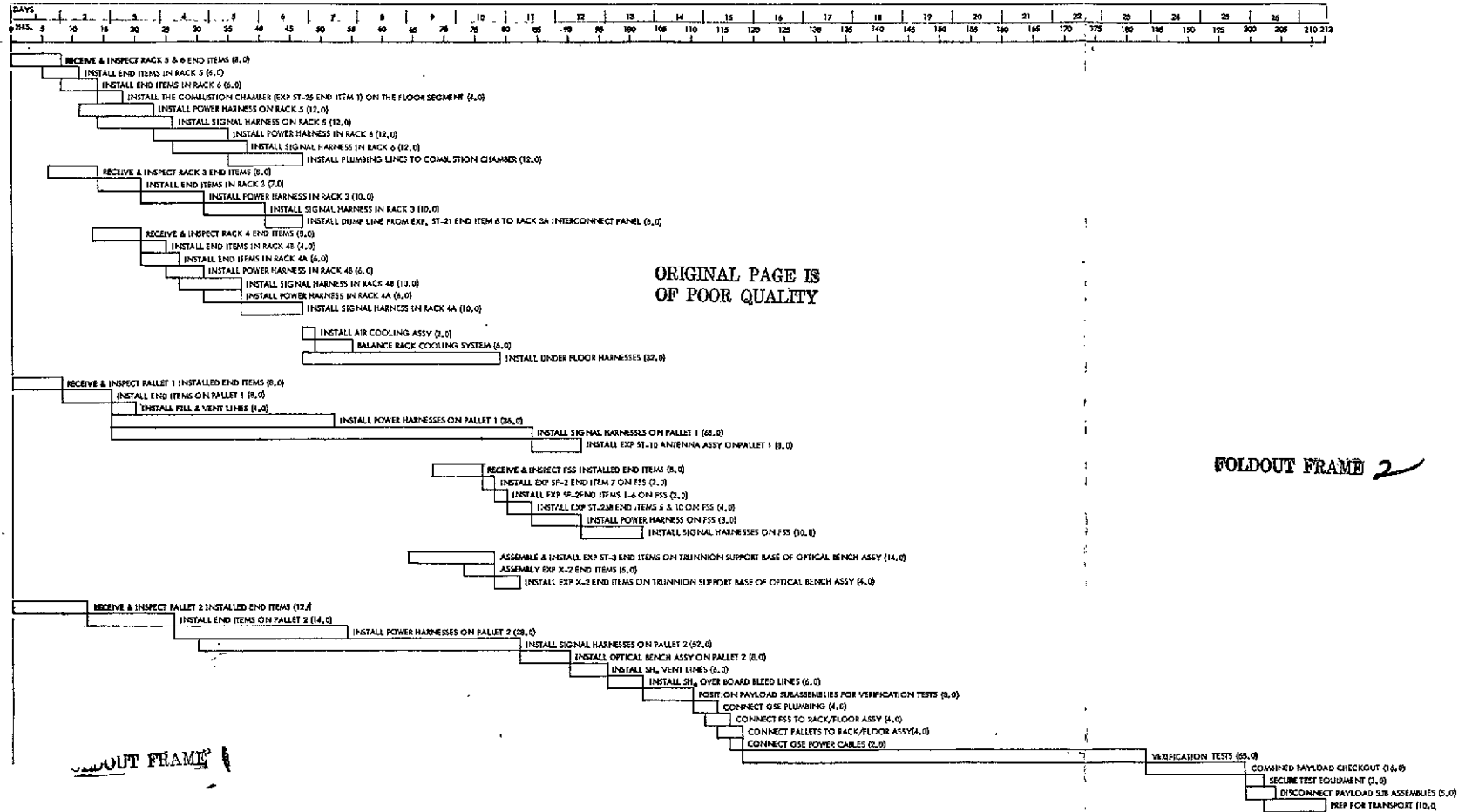


Figure 3-67, ATL Lead Center/KSC Processing Flow, Options B-4 and C-4

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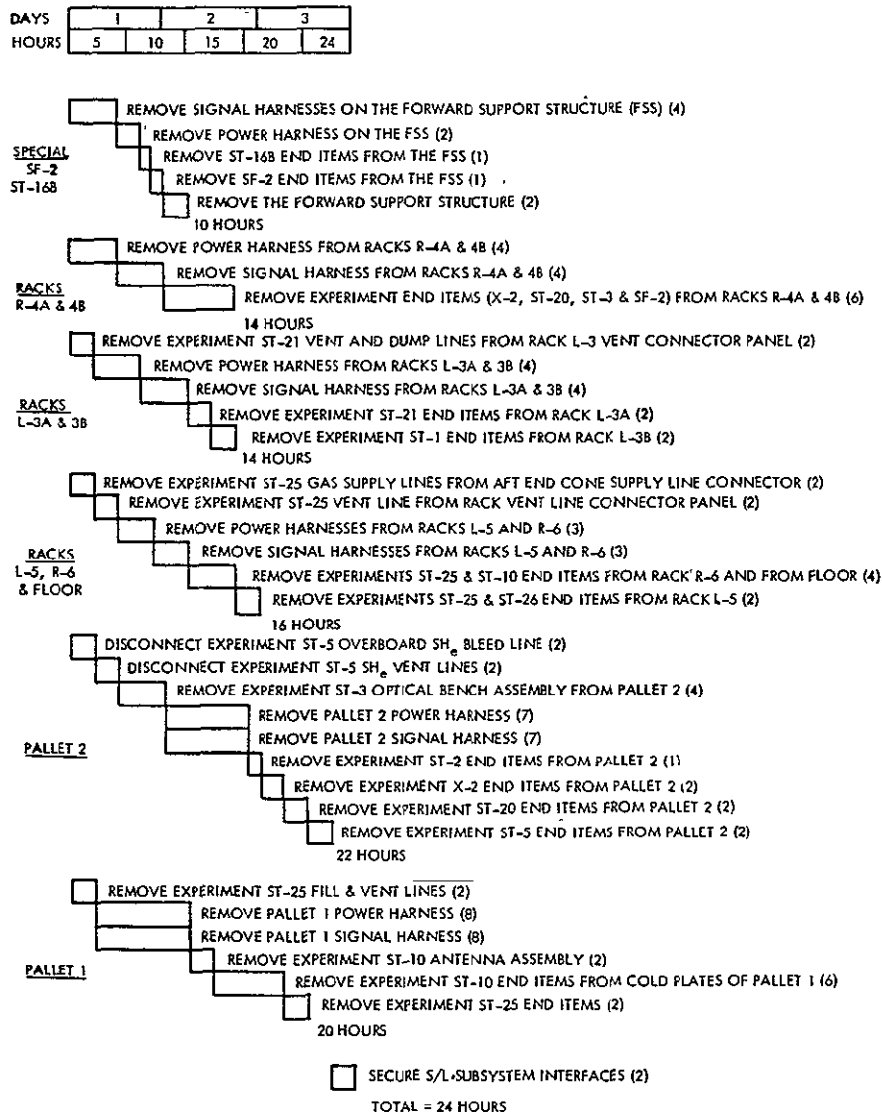


Figure 3-68, ATL Level IV Deintegration

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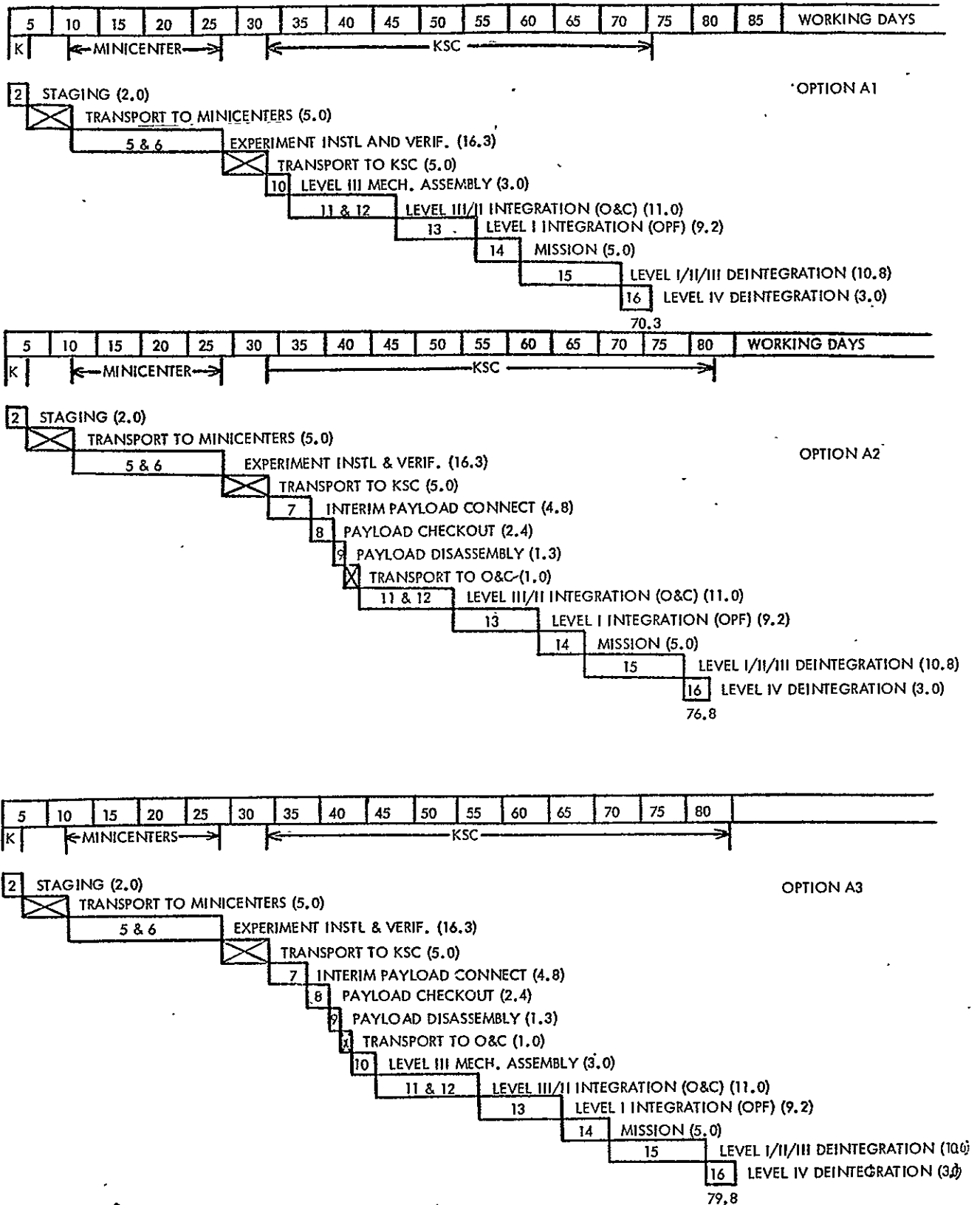


Figure 3-69. ATL Total Ground Processing Flow
Concepts A-1, A-2, A-3

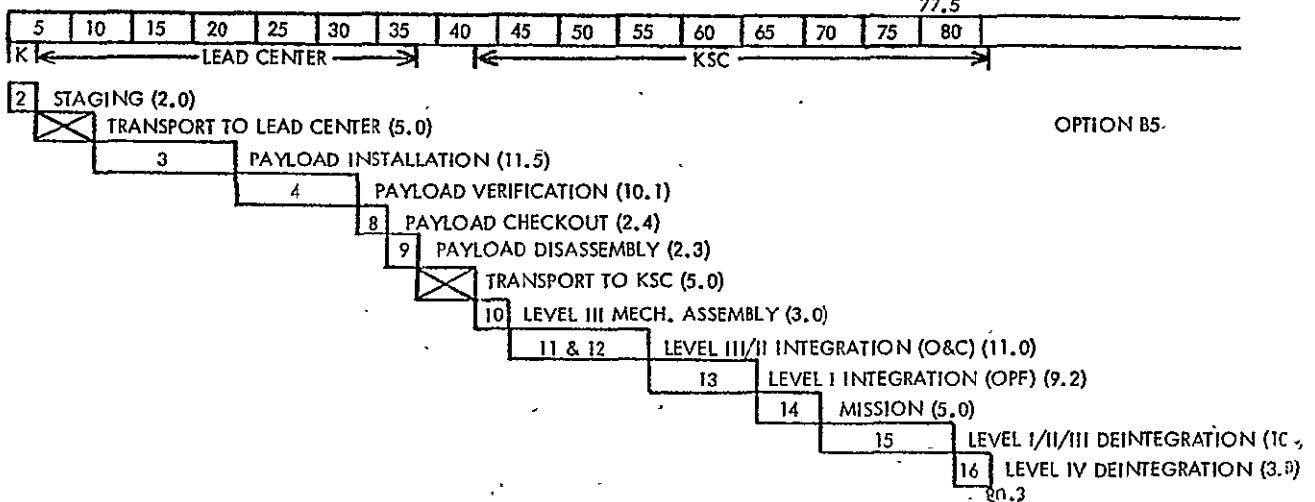
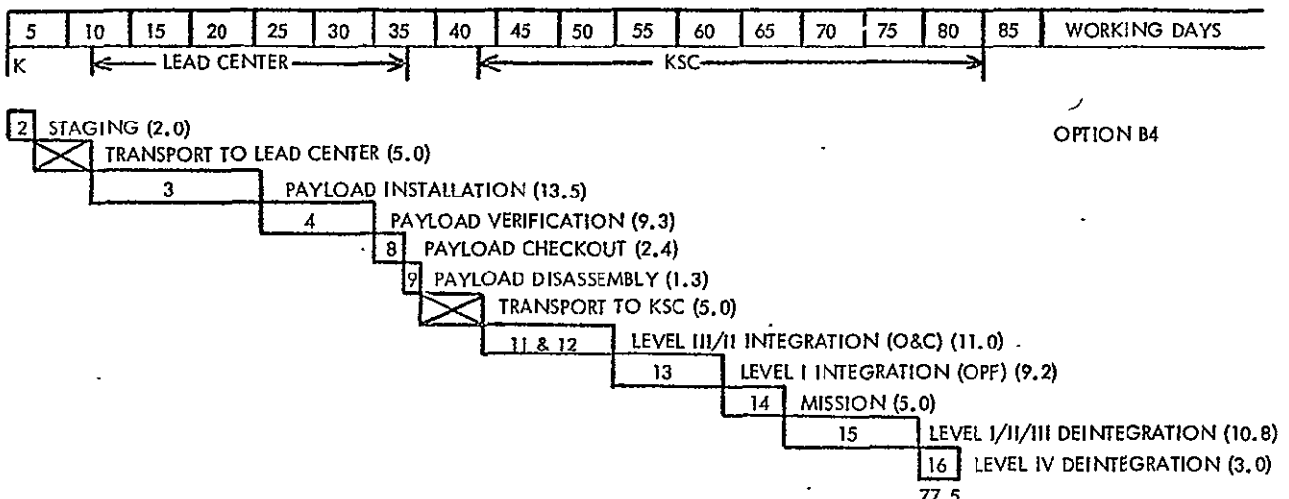
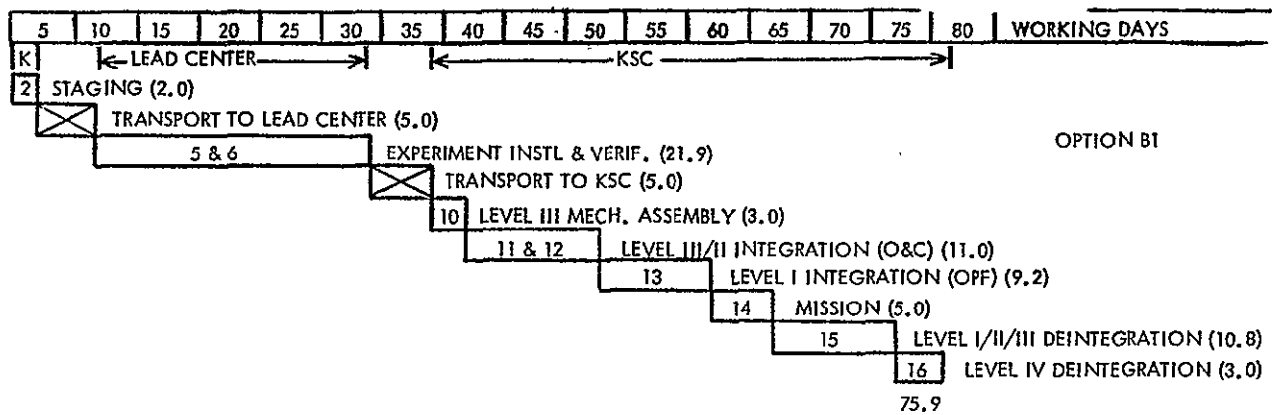


Figure 3-70. ATL Total Ground Processing Flow
Concepts B-1, B-4, B-5

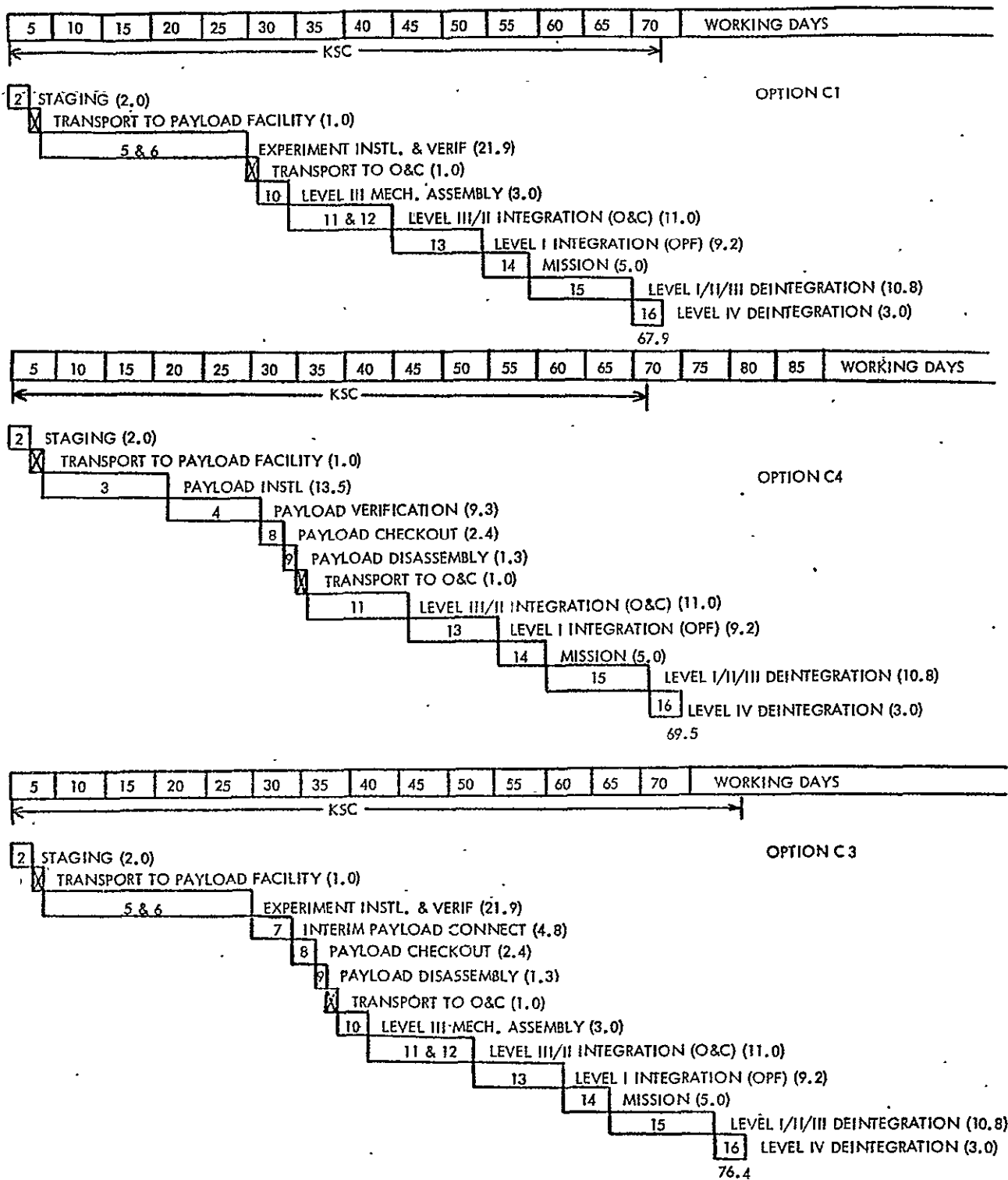


Figure 3-71. ATL Total Ground Processing Flow
Concepts C-1, C-3, C-4

4.0 LEVEL IV INTEGRATION RESOURCE REQUIREMENTS



4.0 LEVEL IV INTEGRATION RESOURCE REQUIREMENTS

Estimates of the resources required for each of the applicable ground processing options for the four representative payloads were developed. The resources addressed were personnel, temporary relocation (TDY), transportation, GSE, and Spacelab flight hardware. The waterfalls presented in Section 3 for each of the options were the basis for the definition of the tasks, the required manpower, and the involvement times of the GSE and flight hardware. Transportation estimates reflect the variations of inter/intra-site shipments for the various options.

PERSONNEL REQUIREMENTS

Three categories of personnel were considered, hands-on personnel, host-center support, and STS operations support. The hands-on personnel estimates reflect the engineers, technicians and quality assurance personnel that perform the installation, checkout, integration, inspection, etc. with the experiment and Spacelab hardware. Host-center support personnel estimates reflect those engineers and technicians at a lead center or KSC required to assist hands-on personnel in accomplishing the integration activities at an unfamiliar site with unique equipments and support procedures. STS operations support personnel estimates reflect the on-site support of the Level IV integration at KSC during Spacelab and Orbiter integration activities. The hands-on effort associated with STS operations was assumed to be accomplished by KSC personnel and was not included in these estimates.

Hands-On Personnel Requirements

These estimates were based upon the specific tasks of Level IV integration delineated in the waterfalls for each option for each payload presented in Section 3. Each task was analyzed to establish the engineer, technician and quality assurance personnel required. Both the scope of the task as well as the accessibility of the equipment and the time estimates were considered in developing realistic manpower estimates.

Estimating Methodology

Initially, the manhours required (by skill level) for each task were estimated. As parallel activities frequently occurred during the ground processing cycle, manpower estimates were summed as a function of the processing times. These summations were converted to personnel requirements, which resulted in a slight increase in available manpower.

Where appropriate, a weighted personnel requirement was established for each phase of the integration activity. For an example, during installation activities technician support requirements could vary significantly from day to day. It would be unrealistic to assume that personnel would be available on a sporadic need basis. Therefore, the total man-days of technical support for the installation activity was divided by the days of the activity to obtain the average requirement. This average personnel level was then compared to the peak requirement. Activities preceding and following the peak activity were assessed



to determine if the task could be extended in duration and thus reduce the peak manpower requirement. The net result of these analyses was an increase in the personnel requirements of about 10% above the absolute manpower estimates for each individual task. It is noted that a more detailed trade-off should be conducted to select a final method of averaging. If the overall ground processing sequence times were extended these new times were included as the final hardware involvement times.

Personnel Estimates

Personnel estimates were summarized by the functional activities (functional blocks) defined in Section 2. These estimates are summarized in Tables 4-1 thru 4-4 for the four representative payloads. For cost estimating purposes mechanical, electrical, and logistics engineers were grouped into one heading. A similar grouping of technicians and inspectors was made. The personnel required for each activity and the total number of working days for that activity are shown in the tables for each applicable option.

Host Center Support Requirements

During the course of the Spacelab program, numerous experiment sponsor/principal investigators/integrators will be involved in the ground processing cycle. It would be misleading to assume that all experiments integrated at a site were sponsored by that site/center. Some of the experimenters/Level IV integrators will be unfamiliar with the equipment and procedures of the host integration site. Therefore, a limited cadre of personnel at the host site will be required to support the visiting experimenters during integration activities.

The host center support requirements vary as a function of the payload and the processing option. For example, in the case of the distributed site options, host center support is minimal because it is assumed that the distributed site would be at the sponsor/experimenter's facility/laboratory. In the case of KSC options, it was assumed that none of the experimenters were normally stationed at KSC; and thus, host center support would be maximum.

The estimated host center support requirements for each applicable option for each payload are summarized in Tables 4-5 thru 4-8. Note that the estimates for lead center options are significantly less than for KSC options but more than for distributed site options. The rationale was that limited support from experimenters normally stationed at the lead center could be utilized.

STS Operations Support

Although the actual hands-on work during STS operations will be performed by KSC personnel experimenter personnel will be required during these activities. Experiment unique interfaces including servicing, test, and launch preparation activities will require experimenter expertise. The estimates of the operations support requirements for each payload are summarized in Tables 4-9 thru 4-12. The variations between options for a payload reflect the inclusion/exclusion of the level III assembly activities in the O&C building. Time estimates reflect the current KSC operational planning flows.

Table 4-1. Space Processing
Manpower Requirements

Level IV "Hands On" Integration												
Funct. Block	A-1		B-2		B-4		C-2		C-4			
	E	T	E	T	E	T	E	T	E	T	E	T
3					5	14			5	14		
4					5	14			5	14		
5	5	14	5	14			5	14				
6	2	14	2	14			2	4				
7												
8			1	3	1	3	1	3	1	3		
9			1	4	1	4	1	4	1	4		

Table 4-2. Combined Astronomy
Manpower Requirements

Level IV "Hands On" Integration																								
Funct. Block	A-1 MC-1		A-1 MC-2		A-1 MC-3		A-2 MC-1		A-2 MC-2		A-2 MC-3		B-1		B-2		B-4		C-1		C-2		C-4	
	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T
3																	7	26					7	26
4																	3	10					3	10
5	3	10	5	18	3	10	3	10	5	18	3	10	9	30	9	30			9	30	9	30		
6	4	10	3	9	3	9	4	10	3	9	3	9	8	25	8	25			8	25	8	25		
7							Note (1)		2	7					2	7					2	7		
8									4	11					4	11	4	11			4	11	4	11
9									4	13					4	13	4	13			4	13	4	13

Note (1) This effort performed at KSC

Table 4-3. Life Sciences Manpower Requirements

Level IV "Hands On" Integration																		
Funct. Block	A-1 MC-1		A-1 MC-2		A-1 MC-3		A-1 MC-4		A-1 MC-5		A-1 MC-6		A-1 MC-7		A-1 MC-8		C-1	
	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T
3																	8	13
4																	4	4
5	3	6	3	5	3	5	2	3	2	4	3	7	3	5	3	7	8	13
6	2	3	2	4	3	5	2	3	2	3	2	3	2	4	3	3	3	3
7																	2	4
8																	4	3
9																	2	4

Funct. Block	A-3 MC-1		A-3 MC-2		A-3 MC-3		A-3 MC-4		A-3 MC-5		A-3 MC-6		A-3 MC-7		A-3 MC-8		B-1		B-3		B-4		B-5	
	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T
3																					8	13	8	13
4																					4	4	4	4
5	3	6	3	5	3	5	2	3	2	4	3	7	3	5	3	7	8	13	8	13				
6	2	3	2	4	3	5	2	3	2	3	2	3	2	4	3	3	3	3	3	3				
7																					2	4		
8																					4	3	8	3
9																					2	4	2	10

Note (1) This effort performed at KSC

Table 4-4. ATL Manpower Requirements

Level IV "Hands On" Integration												
Funct. Block	A-1 MC-1		A-1 MC-2		A-1 MC-3		A-3 MC-1		A-3 MC-2		A-3 MC-3	
	E	T	E	T	E	T	E	T	E	T	E	T
3												
4												
5	4	10	2	6	4	10	4	10	2	6	4	10
6	4	10	2	6	4	10	4	10	2	6	4	10
7							Note (1) 2		7			
8									4	12		
9									4	12		

Note (1) This effort is performed at KSC

Table 4-5. Space Processing Host Center Support Requirements

Host Center Support												
Funct. Block	A-1		B-2		B-4		C-2		C-4			
	E	T	E	T	E	T	E	T	E	T	E	T
3 thru 9	1		1		1		1		1			
16	2	4	2	4	2	4	2	4	2	4		

Table 4-6. Combined Astronomy Host Center Support Requirements

Host Center Support																								
Funct. Block	A-1 MC-1		A-1 MC-2		A-1 MC-3		A-2 MC-1		A-2 MC-2		A-2 MC-3		B-1		B-2		B-4		C-1		C-2		C-4	
	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T
3 thru 9							Note ①		2				1		1		1		2		2		2	
16	Note ①		2	2					2	2			2	2	2	2	2	2	2	2	2	2	2	2

Note ① This effort performed at KSC

Table 4-7. Life Sciences Host Center Support Requirements

Host Center Support																						
Funct. Block	A-1 MC-1		A-1 MC-2		A-1 MC-3		A-1 MC-4		A-1 MC-5		A-1 MC-6		A-1 MC-7		A-1 MC-8		C-1		C-3		C-4	
	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T
3 thru 9	Note ①						None										2		2		2	
16							2	2									2	2	2	2	2	2

Funct. Block	A-3 MC-1		A-3 MC-2		A-3 MC-3		A-3 MC-4		A-3 MC-5		A-3 MC-6		A-3 MC-7		A-3 MC-8		B-1		B-3		B-4		B-5	
	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T
3 thru 9	Note ①						2										1		1		1		1	
16							2	2									2	2	2	2	2	2	2	2

Note ① This effort performed at KSC

Table 4-8. ATL Host Center Support Requirements

Host Center Support												
Funct. Block	A-1 MC-1		A-1 MC-2		A-1 MC-3		A-3 MC-1		A-3 MC-2		A-3 MC-3	
	E	T	E	T	E	T	E	T	E	T	E	T
3 thru 9							Note ①		2			
16	Note ①		2	2			Note ①		2	2		

Funct. Block	B-1		B-3		B-4		B-5		C-1		C-3		C-4	
	E	T	E	T	E	T	E	T	E	T	E	T	E	T
3 thru 9	1		1		1		1		2		2		2	
16	2	2	2	2	2	2	2	2	2	2	2	2	2	2

Note ① This effort performed at KSC

Table 4-9. Space Processing STS Operations Support

KSC Operations Support

Funct. Block	A-1		B-2		B-4		C-2		C-4	
	E	T	E	T	E	T	E	T	E	T
10 thru 15	1	1	1	1	1	1	1	1	1	1
16	1	4	2	4	2	4	2	4	2	4

Table 4-10. Combined Astronomy STS Operations Support

KSC Operations Support

Funct. Block	A-1 MC-1		A-1 MC-2		A-1 MC-3		A-2 MC-1		A-2 MC-2		A-2 MC-3		B-1		B-2		B-4		C-1		C-2		C-4	
	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T
10 thru 15	Note ①		3	1			Note ①		3	1			3	1	3	1	3	1	3	1	3	1	3	1
16			4	17					4	17			4	17	4	17	4	17	4	17	4	17	4	17

Note ① This effort performed at KSC

Table 4-11. Life Sciences STS Operations Support

KSC Operations Support

Funct. Block	A-1 MC-1		A-1 MC-2		A-1 MC-3		A-1 MC-4		A-1 MC-5		A-1 MC-6		A-1 MC-7		A-1 MC-8		C-1		C-3		C-4	
	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T
10 thru 15	Note ①						4	2									4	2	4	2	4	2
16							8	15									8	15	8	15	8	15

Funct. Block	A-3 MC-1		A-3 MC-2		A-3 MC-3		A-3 MC-4		A-3 MC-5		A-3 MC-6		A-3 MC-7		A-3 MC-8		B-1		B-3		B-4		B-5	
	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T
10 thru 15	Note ①						4	2									4	2	4	2	4	2	4	2
16							8	15									8	15	8	15	8	15	8	15

Note ① This effort is performed at KSC

Table 4-12. ATL STS Operations Support

KSC Operations Support

Funct. Block	A-1 MC-1		A-1 MC-2		A-1 MC-3		A-3 MC-1		A-3 MC-2		A-3 MC-3	
	E	T	E	T	E	T	E	T	E	T	E	T
10 thru 15	Note ①		4	2			Note ①		4	2		
16			5	15					4	15		

Funct. Block	B-1		B-3		B-4		B-5		C-1		C-3		C-4	
	E	T	E	T	E	T	E	T	E	T	E	T	E	T
10 thru 15	4	2	4	2	4	2	4	2	4	2	4	2	4	2
16	5	15	5	15	5	15	5	15	5	15	5	15	5	15

Note ① This effort is performed at KSC





Personnel Cost Requirements

Nominal yearly salaries of \$70K and \$60K were assumed for engineers and technicians skill levels respectively. These salaries reflect consideration of overhead/institutional base support as well as direct wages. As all time estimates were based upon working days personnel costs were developed as a function of the available working days per year. The nominal number of available working days per year is 250 after consideration of weekends, holidays, vacations, and sick leave.

Personnel costs for the four categories are summarized in Tables 4-13 thru 4-16 for the four payloads.

Table 4-13. Space Processing Summary Personnel Costs

Option	A-1	B-2	B-4	C-2	C-4
Level IV	\$ 85K	\$ 85K	\$ 89K	\$ 86K	\$ 89K
KSC Ops Support	34	34	34	34	34
Host Center		9	5	14	11
TDY	21	28	28	44	44
TOTAL	\$140K	\$156K	\$156K	\$178K	\$178K

Table 4-14. Combined Astronomy Summary Personnel Costs

Option	A-1	A-2	B-1	B-2	B-4	C-1	C-2	C-4
Level IV	\$125K	\$159K	\$125K	\$152K	\$122K	\$125K	\$164K	\$122K
KSC Ops Support	39	39	39	39	39	39	39	39
Host Ctr	3	9	10	10	9	16	10	15
TDY	20	32	26	35	37	62	67	60
TOTAL	\$187K	\$239K	\$200K	\$236K	\$207K	\$242K	\$280K	\$236K

Table 4-15. Life Sciences Summary Personnel Costs

Option	A-1	A-3	B-1	B-3	B-4	B-5	C-1	C-3	C-4
Level IV	\$121K	\$136K	\$ 89K	\$103K	\$ 92K	\$ 93K	\$ 89K	\$103K	\$ 92K
KSC Ops Support	70	70	70	70	60	70	70	70	60
Host Ctr	2	6	4	5	6	6	10	14	16
TDY	22	31	24	36	35	33	53	57	56
TOTAL	\$215K	\$243K	\$197K	\$214K	\$193K	\$202K	\$222K	\$244K	\$224K

Table 4-16. ATL Summary Personnel Costs

Option	A-1	A-3	B-1	B-3	B-4	B-5	C-1	C-3	C-4
Level IV	\$128K	\$153K	\$128K	\$136K	\$138K	\$149K	\$128K	\$143K	\$138K
KSC Ops Support	63	63	63	63	53	53	63	63	53
Host Ctr	3	8	9	10	10	10	15	17	18
TDY	31	41	39	40	49	50	58	60	76
TOTAL	\$225K	\$265K	\$239K	\$249K	\$251K	\$262K	\$264K	\$283K	\$285K



TEMPORARY RELOCATION REQUIREMENTS (TDY)

Travel and subsistence costs for personnel to support Level IV integration activities at remote site and to support STS operations at KSC are a significant factor. Average costs for TDY are about \$75 per day. Tables 4-17 thru 4-20 summarize the TDY requirements for the applicable options for the four payloads. All Level IV integration personnel were assumed to be on TDY in the KSC options. One-half of the personnel required for Level IV integration activities at a lead center are assumed to be on TDY. If multiple experiments were integrated at a distributed site, it was assumed the most complex/maximum support experiment was sponsored by the distributed site. The personnel associated with the other experiments at a distributed site were assumed to be on TDY status.

TRANSPORTATION REQUIREMENTS

The costs of shipment of Spacelab flight and GSE hardware to/from Level IV integration sites other than at KSC were predicated upon the total number of end items and the width of the shipment. Shipments requiring an outsized carrier - greater than 8 feet in width - required five working days and cost \$4000. Standard shipments of 8 foot in width were assumed to require two days and cost \$3000.

Shipments within the KSC complex were assumed to require one day and cost \$1000.

No costs were included for shipment of experiment equipments. It was assumed that these costs would be independent of the processing option because the site of manufacture/assembly of the experiment equipment could be at a vendor, contractor, laboratory, university, etc., and thus, shipment to the integration site would be required in all options.

In the development of transportation costs partial shipments of equipment were avoided. If a complement of end items was estimated to require a complete truck-load, then a shipment was assumed. But piece-meal shipment of end items as a function of specific need times was not considered (see the subsequent GSE Requirements section).

Tables 4-21 thru 4-24 summarize the transportation/shipment requirements and costs for each payload and their applicable processing options. Distributed site options are the most costly because of the duplication of out-sized carrier shipments. Lead center option costs reflect the feasibility of multiple out-sized elements contained in one shipment. As expected KSC shipment costs are minimal.

GSE REQUIREMENTS

The GSE end items required for Level IV integration with each of the processing options were identified in Section 3. The duration of use and prorated costs of these end items is presented in this section.

Table 4-17. Space Processing TDY Costs

TDY Support											
Funct. Block	A-1		B-2		B-4		C-2		C-4		
	E	T	E	T	E	T	E	T	E	T	
3					3	7			5	14	
4					3	7			5	14	
5	1	4	3	7			5	14			
6	1	4	1	7			2	14			
7											
8					1	2	1	3			
9					1	2	1	4			
10 thru 15	1	1	1	1	1	1	1	1	1	1	
16	2	4	2	4	2	4	2	4	2	4	

Table 4-18. Combined Astronomy TDY Costs

TDY Support																								
Funct. Block	A-1 MC-1		A-1 MC-2		A-1 MC-3		A-2 MC-1		A-2 MC-2		A-2 MC-3		B-1		B-2		B-4		C-1		C-2		C-4	
	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T
3																	4	13					4	13
4																	2	5					2	5
5	1	3	1	4	1	2	1	3	1	4	1	2	4	15	4	15			4	15	4	15		
6	1	3	1	2	1	2	1	3	1	2	1	2	4	12	4	12			4	12	4	12		
7							Note ①					2	7								2	7		
8									4	11					2	6	2	6			4	11	4	11
9									4	13					2	6	2	6			4	13	4	13
10 thru 15	Note ①		3	1					3	1			3	1	3	1	3	1	3	1	3	1	3	1
16			4	17					4	17			4	17	4	17	4	17	4	17	4	17	4	17

Note ① This effort is performed at KSC

Table 4-19. Life Sciences TDY Costs

TDY Support																								
Funct. Block	A-1 MC-1		A-1 MC-2		A-1 MC-3		A-1 MC-4		A-1 MC-5		A-1 MC-6		A-1 MC-7		A-1 MC-8		C-1		C-3		C-4			
	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T		
3																						8	13	
4																						4	4	
5	1	2	1	1	1	1	1	1	1	1	2	1	1	1	2	8	13	8	13					
6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	3	3	3					
7																			2	4				
8																			4	3	8	3		
9																		2	4	2	4			
10 thru 15	Note ①						4	2									4	2	4	2	4	2		
16							8	15									8	15	8	15	8	15		

Note ① This effort is performed at KSC

Table 4-19. Life Sciences TDY Costs (Cont'd)

TDY Support (Cont'd)																															
Funct. Block	A-3 MC-1		A-3 MC-2		A-3 MC-3		A-3 MC-4		A-3 MC-5		A-3 MC-6		A-3 MC-7		A-3 MC-8		B-1		B-3		B-4		B-5								
	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T							
3																							4	6	4	6					
4																							2	2	2	2					
5	1	2	1	1	1	1	1	1	1	1	2	1	1	1	2	2	4	2	4												
6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2												
7																			1	2											
8																			2	2	4	2									
9																				1	2	1	2	1	5						
10 thru 15	Note ①																							4	2						
16																															

Note ① This effort is performed at KSC



Table 4-20. ATL TDY Costs

TDY Support																											
Funct. Block	A-1 MC-1		A-1 MC-2		A-1 MC-3		A-3 MC-1		A-3 MC-2		A-3 MC-3		B-1		B-3		B-4		B-5		C-1		C-3		C-4		
	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T	
3																	4	10	4	10					8	21	
4																	4	10	4	10					8	21	
5	1	3	1	1	1	3	1	3	1	1	1	3	4	12	4	12					9	24	9	24			
6	1	3	1	1	1	3	1	3	1	1	1	3	4	12	4	12					9	24	9	24			
7							Note ① 2 7								1	3							2	7			
8									4	12					2	6	2	6	2	6			4	12	4	12	
9									4	12					2	6	2	6	2	6			4	12	4	12	
10 thru 15	Note ①		4	2					4	2			4	2	4	2	4	2	4	2	4	2	4	2	4	2	
16			5	15					5	15			5	15	5	15	5	15	5	15	5	15	5	15	5	15	

Note ① This effort is performed at KSC

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Table 4-21. Space Processing Transportation Requirements

Payload	Processing Option	Transportation Equipment (To/From Level IV)	Unit Cost (\$K)	Total Cost (\$K)
Space Processing	A-2	2 Wide Loads 1 Standard Loads (Vans) 2 Partial Std Loads (Vans)	4.0 3.0 2.0	8.0 3.0 4.0 15.0
	B-2	2 Wide Loads 1 Standard Loads (Vans) 2 Partial Std Loads (Vans)	4.0 3.0 2.0	8.0 3.0 4.0 15.0
	B-4	2 Wide Loads 1 Standard Loads (Vans) 2 Partial Std Loads (Vans)	4.0 3.0 2.0	8.0 3.0 4.0 15.0
	C-2	2 Wide Loads (KSC) 1 Standard Loads (Vans) (KSC) 2 Partial Std Loads (Vans) (KSC)	1.0 1.0 .5	2.0 1.0 1.0 4.0
	C-4	2 Wide Loads (KSC) 1 Standard Loads (Vans) (KSC) 2 Partial Std Loads (Vans) (KSC)	1.0 1.0 .5	2.0 1.0 1.0 4.0



Table 4-22. Combined Astronomy
Transportation Requirements

Payload	Processing Option	Transportation Equipment (To/From Level IV)	Unit Cost (\$K)	Total Cost (\$K)
Combined Astronomy	A-1	6 Wide Loads	4.0	24.0
		6 Standard Loads (Vans)	3.0	18.0
				42.0
	A-2	6 Wide Loads	4.0	24.0
		6 Standard Loads (Vans)	3.0	18.0
		2 Partial Wide Loads (KSC)	1.0	2.0
		1 Partial Std Loads (Vans) (KSC)	1.0	1.0
				45.0
	B-1	4 Wide Loads	4.0	16.0
		2 Standard Loads (Vans)	3.0	6.0
				22.0
	B-2	4 Wide Loads	4.0	16.0
		2 Standard Loads (Vans)	3.0	6.0
				22.0
	B-4	4 Wide Loads	4.0	16.0
		2 Standard Loads (Vans)	3.0	6.0
				22.0
	C-1	4 Partial Wide Loads (KSC)	.5	2.0
		2 Partial Std Loads (Vans) (KSC)	.5	1.0
				3.0
	C-2	4 Partial Wide Loads (KSC)	.5	2.0
		2 Partial Std Loads (Vans) (KSC)	.5	1.0
				3.0
	C-4	4 Partial Wide Loads (KSC)	.5	2.0
		2 Partial Std Loads (Vans) (KSC)	.5	1.0
				3.0

Table 4-23. Life Sciences
Transportation Requirements

Payload	Processing Option	Transportation Equipment (To/From Level IV)	Unit Cost (\$K)	Total Cost (\$K)
Life Sciences	A-1	4 Wide Loads	5.0	20.0
		16 Standard Loads (Vans)	3.0	48.0
		2 Partial Std Loads (Vans)	1.0	2.0
				70.0
	A-3	4 Wide Loads	5.0	20.0
		16 Standard Loads (Vans)	3.0	48.0
		2 Partial Std Loads (Vans)	1.0	2.0
				70.0
	B-1	2 Wide Loads	5.5	11.0
		2 Standard Loads (Vans)	3.0	6.0
				17.0
	B-3	2 Wide Loads	5.5	11.0
		2 Standard Loads (Vans)	3.0	6.0
				17.0
	B-4	2 Wide Loads	5.5	11.0
		2 Standard Loads (Vans)	3.0	6.0
				17.0
	B-5	2 Wide Loads	5.5	11.0
		2 Standard Loads (Vans)	3.0	6.0
				17.0
	C-1	1 Wide Load (KSC)	3.0	3.0
				3.0
	C-3	1 Wide Load (KSC)	3.0	3.0
				3.0
	C-4	1 Wide Load (KSC)	3.0	3.0
				3.0

Table 4-24. ATL Transportation Requirements

Payload	Processing Option	Transportation Equipment (To/From Level IV)	Unit Cost (\$K)	Total Cost (\$K)
ATL	A-1	4 Wide Loads	4.0	16.0
		6 Standard Loads (Vans)	3.0	18.0
				34.0
	A-3	4 Wide Loads	4.0	16.0
		6 Standard Loads (Vans)	3.0	18.0
				34.0
	B-1	2 Wide Loads	4.0	8.0
		2 Standard Loads (Vans)	3.0	6.0
				14.0
	B-3	2 Wide Loads	4.0	8.0
		2 Standard Loads (Vans)	3.0	6.0
				14.0
	B-4	2 Wide Loads	4.0	8.0
		2 Standard Loads (Vans)	3.0	6.0
				14.0
	B-5	2 Wide Loads	4.0	8.0
		2 Standard Loads (Vans)	3.0	6.0
				14.0
	C-1	2 Wide Loads (KSC)	1.0	2.0
		2 Standard Loads (Vans) (KSC)	.5	1.0
				3.0
	C-3	2 Wide Loads (KSC)	1.0	2.0
		2 Standard Loads (Vans) (KSC)	.5	1.0
				3.0
	C-4	2 Wide Loads (KSC)	1.0	2.0
		2 Standard Loads (Vans) (KSC)	.5	1.0
				3.0



End Item Usage

The ground processing task waterfalls were the basis for the establishment of the required period of time for GSE end items. Usage or involvement times of each end item of GSE encompassed pre-flight staging through delivery of the payload for STS operations (in the O&C building) and post-flight deintegration (removal of experiment equipment from Spacelab mounting elements). GSE requirements during STS operations were not included in this study.

The determination of GSE involvement times is illustrated in Figure 4-1.

The actual utilization of each end item of GSE required during the various Level IV ground processing activities is illustrated by the heavy black bars at the left of the figure. The duration of that particular usage is indicated by the length of the bar and also contained in the parenthesis at the end of each usage. The triangles shown on each GSE end item are the shipment times, both to and from KSC. These shipment times do not correlate exactly to the end of the usage of a piece of equipment. They have been grouped into logical units that represent a full (standard van) load that would be transported to KSC for future assignment to another Level IV integration activity. The figures containing the involvement times for each item of GSE in all processing options are contained in Appendix E.

The GSE requirements of each processing option were evaluated based on the following:

- a. Operational processing time for each installation, checkout, shipment, assembly, and disassembly operation.
- b. Actual GSE utilization time for each operation.
- c. Total GSE involvement time from first Level IV usage or transport of the GSE item to the transport of the GSE item to the next user.
- d. Quantity of each GSE item and unit cost.
- e. Prorated cost per flight.

GSE Requirements Estimates

A summary of the GSE Utilization/Involvement Time charts which identified the GSE prorated cost per flights are shown in Table 4-25 for the Space Processing payload. Table 4-26 covers the Combined Astronomy payload GSE requirements, Table 4-27 covers the Life Science payload GSE requirements, and Table 4-28 covers the ATL payload GSE requirements.

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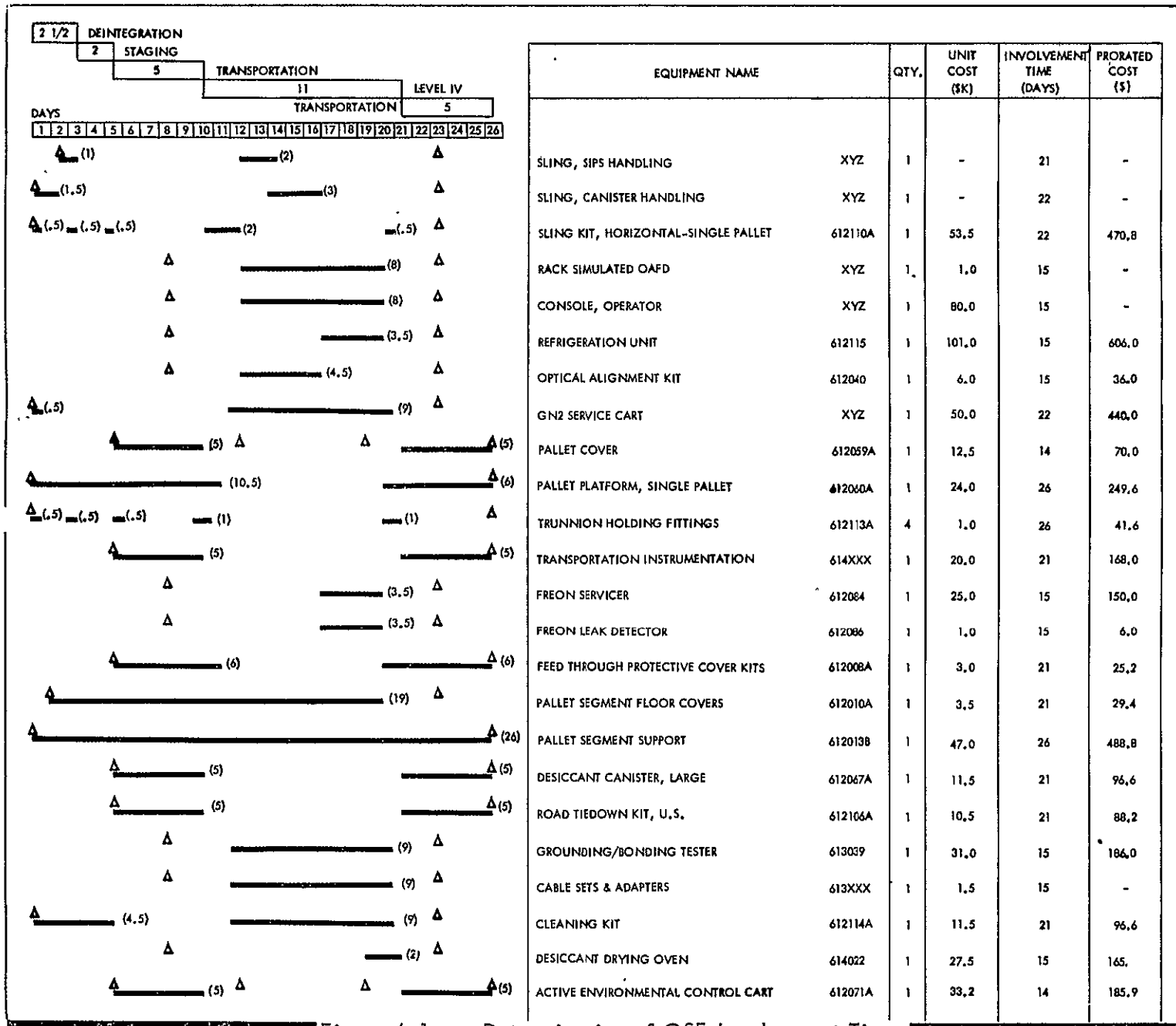


Figure 4-1. Determination of GSE Involvement Times



Table 4-25. Space Processing GSE Requirements (Sheet 1 of 2)

Quantity	Equipment Name		Unit Cost (\$)	Location		Prorated Cost/Flt(\$)
				Center	Option	
					B-4	
1	Feedthru Covers	612008	3,210	41		53
1	Pallet Seg. Floor Covers	612010	3,440	38		52
1	Pallet Seg. Support	612013	46,950	41		770
1	Pallet Cover	612059	12,610	32		161
1	Pallet Platform	612060	24,050	41		394
3	LG Desiccant Canister	612067	11,450	32		440
1	Road Tiedown Kit	612106	10,700	32		137
1	Horizontal Sling	612110	53,500	29		621
4	Trunnion Handling Fittings	612113	1,000	41		70
1	Transport Instrumentation		20,000	32		256
1	Ground/Bond Tester	613039	30,920	29		136
6	Cable Set and Adapters		1,180	17		-
1	Portable Leak Detector	612080	2,290	12		-
1	Freon Servicer	612084	25,190	12		121
1	Freon Leak Detector	612086	1,144	12		5
1	Refrig Unit	612115	181,370	12		871
1	Cleaning Kit	612114	11,450	31		142
1	Desiccant Oven	614022	27,480	6		66
1	Operator's Console		80,000	29		928
1	PSS Panel Rack		1,000	29		12
1	Active ECS Cart	612071	33,210	32		425
						5660

Table 4-25. Space Processing GSE Requirements (Sheet 2 of 2)

Quantity	Equipment Name		Unit Cost (\$)	Location		Prorated Cost/Flt(\$)
				Center	Option	
					C-4	
1	Feedthru Covers	612008	3,210	33		42
1	Pallet Seg. Floor Covers	612010	3,440	33		45
1	Pallet Seg. Support	612013	46,950	33		620
1	Pallet Cover	612059	12,610	24		121
1	Pallet Platform	612060	24,050	33		317
3	LG Desiccant Canister	612067	11,450	24		330
1	Road Tiedown Kit	612106	10,700	24		17
1	Horizontal Sling	612110	53,500	26		556
4	Trunnion Handling Fittings	612113	1,000	26		45
1	Transport Instrumentation		20,000	24		192
1	Ground/Bond Tester	613039	30,920	7		87
6	Cable Set and Adapters		1,180	13		-
1	Portable Leak Detector	612080	2,290	2		-
1	Freon Servicer	612084	25,190	8		81
1	Freon Leak Detector	612086	1,144	2		1
1	Refrig Unit	612115	181,370	8		580
1	Cleaning Kit	612114	11,450	25		115
1	Desiccant Oven	614022	27,480	22		242
1	Operator's Console		80,000	14		448
1	PSS Panel Rack		1,000	14		6
1	Active ECS Cart	612071	33,210	24		319
						4163

Table 4-26. Combined Astronomy GSE Requirements (Sheet 1 of 8)

GSE REQUIREMENTS-COMBINED ASTRONOMY Location Site #1 Option A-1

Quantity	Equipment Name	Unit Cost (\$ K)	Involvm't Time(Days)	Prorated Cost Flt(\$)
0	Vertical Sling Kit 612006	10.5	-	-
1	Feed Thru Protective Covers 612008	3.0	21	25
1	Pallet Segment Floor Covers 612010	3.5	21	29
1	Pallet Segment Support-Single 612013	47.0	26	489
0	Pallet Segment Support-Double 612013	-	-	-
1	Pallet Cover 612059	12.5	14	70
1	Pallet Platform-Single Pallet 612060	24.0	26	250
0	Pallet Platform-Double Pallet 612060	48.0	-	-
0	Rack, PSS Panel 612XXX	9.0	-	-
1	Desiccant Canister-Large 612067	11.5	21	97
1	Active Environmental Control Cart 612071	33.0	14	186
1	Road Transport Tie Down Kit 612106	10.5	21	88
1	Horizontal Sling Kit 612110	53.5	22	471
4	Trunnion Handling Fittings 612113	1.0	26	42
1	Transportation Instrumentation 614XXX	20.0	21	168
1	Optical Alignment Kit 612040	6.0	15	36
0	IPS Test and Checkout Kit 612208	120.0	-	-
0	Continuity Tester 613038	90.5	-	-
1	Ground/Bonding Tester 613039	31.0	15	186
0	Portable Leak Detector 612080	2.5	-	-
1	Freon Servicer 612084	25.0	15	150
0	Cable Sets and Adapters 613XXX	1.5	-	-
1	Freon Leak-Detector 612086	1.0	15	0
1	Operator's Console 612XXX	80.0	15	-
1	Refrigeration Unit 612115	101.1	15	606
1	GN-2 Service Cart 612XXX	50.0	22	440
1	Vacuum Pumping Unit 612XXX	25.0	15	150
1	Cleaning Kit 612XXX	11.5	21	97
1	Desiccant Drying Oven 614022	27.5	15	165
				3751

Table 4-26. Combined Astronomy GSE Requirements (Sheet 2 of 8)

GSE REQUIREMENTS-COMBINED ASTRONOMY Location Site #2 Option A-1

Quantity	Equipment Name	Unit Cost (\$ K)	Involvm't Time(Days)	Prorated Cost Flt(\$)
0	Vertical Sling Kit 612006	10.5	-	-
2	Feed Thru Protective Covers 612008	3.0	25	90
3	Pallet Segment Floor Covers 612010	3.5	25	105
3	Pallet Segment Support-Single 612013	47.0	29	1636
0	Pallet Segment Support-Double 612013	94.0	-	-
3	Pallet Cover 612059	12.5	25	375
1	Pallet Platform-Single Pallet 612060	24.0	29	278
1	Pallet Platform-Double Pallet 612060	48.0	29	557
0	Rack, PSS Panel 612XXX	9.0	-	-
3	Desiccant Canister-Large 612067	11.5	25	345
1	Active Environmental Control Cart 612071	33.0	25	332
3	Road Transport Tie Down Kit 612106	10.5	25	315
1	Horizontal Sling Kit 612110	53.5	26	556
8	Trunnion Handling Fittings 612113	1.0	26	83
1	Transportation Instrumentation 614XXX	20.0	14	112
1	Optical Alignment Kit 612040	6.0	19	46
1	IPS Test and Checkout Kit 612208	120.0	24	1152
0	Continuity Tester 613038	90.5	-	-
1	Ground/Bonding Tester 613039	31.0	19	236
0	Portable Leak Detector 612080	2.5	-	-
1	Freon Servicer 612084	25.0	19	190
1	Cable Sets and Adapters 613XXX	1.5	19	11
1	Freon Leak Detector 612086	1.0	19	8
1	Operator's Console 612XXX	80.0	19	-
1	Refrigeration Unit 612115	101.1	19	768
0	GN-2 Service Cart 612XXX	50.0	-	-
1	Vacuum Pumping Unit 612XXX	25.0	19	190
1	Cleaning Kit 612XXX	11.5	26	120
1	Desiccant Drying Oven 614022	27.5	18	198
				7673

4-14

SD 78-SR-0009-2

Table 4-26. Combined Astronomy GSE Requirements (Sheet 3 of 8)

GSE REQUIREMENTS-COMBINED ASTRONOMY Location Site #3 Option A-1

Quantity	Equipment Name	Unit Cost (\$ K)	Involvm't Time(Days)	Prorated Cost Flt(\$)
0	Vertical Sling Kit 612006	10.5	-	-
1	Feed Thru Protective Covers 612008	3.0	18	22
1	Pallet Segment Floor Covers 612010	3.5	22	31
1	Pallet Segment Support-Single 612013	47.0	23	432
0	Pallet Segment Support -Double 612013	94.0	-	-
1	Pallet Cover 612059	12.5	18	90
1	Pallet Platform-Single Pallet 612060	24.0	22	211
0	Pallet Platform-Double Pallet 612060	48.0	-	-
0	Rack, PSS Panel 612XXX	9.0	-	-
1	Desiccant Canister-Large 612067	11.5	18	83
1	Active Environmental Control Cart 612071	33.0	18	239
1	Road Transport Tie Down Kit 612106	10.5	18	76
1	Horizontal Sling Kit 612110	53.5	19	407
4	Trunnion Handling Fittings 612113	1.0	22	35
1	Transportation Instrumentation 614XXX	20.0	18	144
1	Optical Alignment Kit 612040	6.0	12	29
0	IPS Test and Checkout Kit 612208	120.0	-	-
0	Continuity Tester 613038	90.0	-	-
1	Ground/Bonding Tester 613039	31.0	12	149
0	Portable Leak Detector 612080	2.5	-	-
1	Freon Servicer 612084	25.0	12	120
1	Cable Sets and Adapters 613XXX	1.5	12	7
1	Freon Leak Detector 612086	1.0	12	5
0	Operator's Console 612XXX	80.0	-	-
1	Refrigeration Unit 612115	101.1	12	485
0	GN-2 Service Cart 612XXX	50.0	-	-
0	Vacuum Pumping Unit 612XXX	25.0	-	-
1	Cleaning Kit 612XXX	11.5	17	78
1	Desiccant Drying Oven 614022	27.5	12	132
				2775

Table 4-26. Combined Astronomy GSE Requirements (Sheet 4 of 8)

GSE REQUIREMENTS-COMBINED ASTRONOMY Location Site #1 Option A-2

Quantity	Equipment Name	Unit Cost (\$ K)	Involvm't Time(Days)	Prorated Cost Flt(\$)
0	Vertical Sling Kit 612006	10.5	-	-
1	Feed Thru Protective Covers 612008	3.0	21	25
1	Pallet Segment Floor Covers 612010	3.5	21	29
1	Pallet Segment Support-Single 612013	47.0	26	489
0	Pallet Segment Support -Double 612013	94.0	-	-
1	Pallet Cover 612059	12.5	14	70
1	Pallet Platform-Single Pallet 612060	24.0	26	250
0	Pallet Platform-Double Pallet 612060	48.0	-	-
0	Rack, PSS Panel 612XXX	9.0	-	-
1	Desiccant Canister-Large 612067	11.5	21	97
1	Active Environmental Control Cart 612071	33.0	14	186
1	Road Transport Tie Down Kit 612106	10.5	21	88
1	Horizontal Sling Kit 612110	53.5	22	471
4	Trunnion Handling Fittings 612113	1.0	26	42
1	Transportation Instrumentation 614XXX	20.0	21	168
1	Optical Alignment Kit 612040	6.0	15	36
0	IPS Test and Checkout Kit 612208	120.0	-	-
0	Continuity Tester 613038	90.5	-	-
1	Ground/Bonding Tester 613039	31.0	15	186
0	Portable Leak Detector 612080	2.5	-	-
1	Freon Servicer 612084	25.0	15	150
0	Cable Sets and Adapters 613XXX	1.5	-	-
1	Freon Leak Detector 612086	1.0	15	6
1	Operator's Console 612XXX	80.0	15	-
1	Refrigeration Unit 612115	101.1	15	606
1	GN-2 Service Cart 612XXX	50.0	22	440
1	Vacuum Pumping Unit 612XXX	25.0	15	250
1	Cleaning Kit 612XXX	11.5	21	97
1	Desiccant Drying Oven 614022	27.5	15	165
				3751

4-15

SD 78-SR-0009-2

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Table 4-26. Combined Astronomy GSE Requirements (Sheet 5 of 8)

GSE REQUIREMENTS-COMBINED ASTRONOMY Location Site #2 Option A-2					
Quantity	Equipment Name	Unit Cost (\$ K)	Invol'm't Time(Days)	Prorated Cost (\$ K)	
0	Vertical Sling Kit	612006	10.5	-	-
2	Feed Thru Protective Covers	612008	3.0	25	60
3	Pallet Segment Floor Covers	612010	3.5	27	113
3	Pallet Segment Support-Single	612013	47.0	30	1692
0	Pallet Segment Support -Double	612013	94.0	-	-
3	Pallet Cover	612059	12.5	25	375
1	Pallet Platform-Single Pallet	612060	24.0	30	288
1	Pallet Platform-Double Pallet	612060	48.0	30	576
0	Rack, PSS Panel	612XXX	9.0	-	-
3	Desiccant Canister-Large	612067	11.5	25	345
1	Active Environmental Control Cart	612071	33.0	25	330
3	Road Transport Tie Down Kit	612106	10.5	25	315
1	Horizontal Sling Kit	612110	53.5	27	578
8	Trunnion Handling Fittings	612113	4.0	30	348
1	Transportation Instrumentation	614XXX	20.0	25	200
1	Optical Alignment Kit	612040	6.0	24	58
1	IPS Test and Checkout Kit	612208	120.0	25	1200
0	Continuity Tester	613038	90.5	-	-
1	Ground/Bonding Tester	613039	31.0	25	310
0	Portable Leak Detector	612080	2.5	-	-
1	Freon Servicer	612084	25.0	19	190
1	Cable Sets and Adapters	613XXX	1.5	19	11
1	Freon Leak Detector	612086	1.0	19	8
1	Operator's Console	612XXX	80.0	25	800
1	Refrigeration Unit	612115	101.1	19	767
0	GN-2 Service Cart	612XXX	50.0	-	-
1	Vacuum Pumping Unit	612XXX	25.0	19	190
1	Cleaning Kit	612XXX	11.5	19	87
1	Desiccant Drying Oven	614022	27.5	19	87
					2944

Table 4-26. Combined Astronomy GSE Requirements (Sheet 6 of 8)

GSE REQUIREMENTS-COMBINED ASTRONOMY Location Site #3 Option A-2					
Quantity	Equipment Name	Unit Cost (\$ K)	Invol'm't Time(Days)	Prorated Cost (\$ K)	
0	Vertical Sling Kit	612006	10.5	-	-
1	Feed Thru Protective Covers	612008	3.0	17	20
1	Pallet Segment Floor Covers	612010	3.5	22	31
1	Pallet Segment Support-Single	612013	47.0	22	414
0	Pallet Segment Support -Double	612013	-	-	-
1	Pallet Cover	612059	12.5	17	85
1	Pallet Platform-Single Pallet	612060	24.0	22	211
0	Pallet Platform-Double Pallet	612060	48.0	-	-
0	Rack, PSS Panel	612XXX	9.0	-	-
1	Desiccant Canister-Large	612067	11.5	17	78
1	Active Environmental Control Cart	612071	33.0	20	266
1	Road Transport Tie Down Kit	612106	10.5	17	71
1	Horizontal Sling Kit	612110	53.5	22	471
4	Trunnion Handling Fittings	612113	1.0	22	35
1	Transportation Instrumentation	614XXX	20.0	20	160
1	Optical Alignment Kit	612040	6.0	11	26
0	IPS Test and Checkout Kit	612208	120.0	-	-
0	Continuity Tester	613038	90.5	-	-
1	Ground/Bonding Tester	613039	31.0	11	136
0	Portable Leak Detector	612080	2.5	-	-
1	Freon Servicer	612084	25.0	11	110
1	Cable Sets and Adapters	613XXX	1.5	11	7
1	Freon Leak Detector	612086	1.0	11	4
1	Operator's Console	612XXX	80.0	17	544
1	Refrigeration Unit	612115	101.1	11	444
0	GN-2 Service Cart	612XXX	50.0	-	-
0	Vacuum Pumping Unit	612XXX	25.0	-	-
1	Cleaning Kit	612XXX	11.5	11	136
1	Desiccant Drying Oven	614022	27.5	11	51
					3215

Table 4-26. Combined Astronomy GSE Requirements (Sheet 7 of 8)

GSE REQUIREMENTS-COMBINED ASTRONOMY Location Center Option B-4				
Quantity	Equipment Name	Unit Cost (\$ K)	Involvement Time (Days)	Prorated Cost (\$ K)
0	Vertical Sling Kit 612006	10.5	-	-
4	Feed Thru Protective Covers 612008	3.0	28	134
5	Pallet Segment Floor Covers 612010	3.5	31	217
3	Pallet Segment Support-Single 612013	47.0	31	1748
1	Pallet Segment Support -Double 612013	94.0	31	1166
5	Pallet Cover 612059	12.5	17	425
3	Pallet Platform-Single Pallet 612060	24.0	20	576
1	Pallet Platform -Double Pallet 612060	48.0	14	269
0	Rack, PSS Panel 612XXX	9.0	-	-
5	Desiccant Canister-Large 612067	11.5	8	184
1	Active Environmental Control Cart 612071	33.0	8	106
4	Road Transport Tie Down Kit 612106	10.5	8	134
2	Horizontal Sling Kit 612110	53.5	31	1326
16	Trunnion Handling Fittings 612113	1.0	31	198
3	Transportation Instrumentation 614XXX	20.0	8	192
1	Optical Alignment Kit 612040	6.0	13	31
1	IPS Test and Checkout Kit 612208	120.0	16	768
0	Continuity Tester 613038	90.5	-	-
1	Ground/Bonding Tester 613039	31.0	21	260
0	Portable Leak Detector 612080	2.5	-	-
1	Freon Servicer 612084	25.0	18	180
0	Cable Sets and Adapters 613XXX	1.5	-	-
1	Freon Leak Detector 612086	1.0	18	72
0	Operator's Console 612XXX	80.0	-	-
1	Refrigeration Unit 612115	101.1	19	768
1	GN-2 Service Cart 612XXX	50.0	20	400
1	Vacuum Pumping Unit 612XXX	25.0	19	190
1	Cleaning Kit 612XXX	11.5	31	143
1	Desiccant Drying Oven 614022	27.5	11	121
				9608

Table 4-26. Combined Astronomy GSE Requirements (Sheet 8 of 8)

GSE REQUIREMENTS-COMBINED ASTRONOMY Location KSC Option C-4				
Quantity	Equipment Name	Unit Cost (\$ K)	Involvement Time (Days)	Prorated Cost (\$ K)
0	Vertical Sling Kit 612006	10.5	-	-
4	Feed Thru Protective Covers 612008	3.0	20	120
5	Pallet Segment Floor Covers 612010	3.5	23	129
3	Pallet Segment Support-Single 612013	47.0	23	1297
1	Pallet Segment Support -Double 612013	94.0	23	865
5	Pallet Cover 612059	12.5	5	125
3	Pallet Platform-Single Pallet 612060	24.0	12	346
1	Pallet Platform -Double Pallet 612060	48.0	12	230
0	Rack, PSS Panel 612XXX	9.0	-	-
5	Desiccant Canister-Large 612067	11.5	5	115
1	Active Environmental Control Cart 612071	33.0	5	66
4	Road Transport Tie Down Kit 612106	10.5	5	84
2	Horizontal Sling Kit 612110	53.5	23	984
16	Trunnion Handling Fittings 612113	1.0	23	147
3	Transportation Instrumentation 614XXX	20.0	5	120
1	Optical Alignment Kit 612040	6.0	11	26
1	IPS Test and Checkout Kit 612208	120.0	12	576
0	Continuity Tester 613038	90.5	-	-
1	Ground/Bonding Tester 613039	31.0	19	236
0	Portable Leak Detector 612080	2.5	-	-
1	Freon Servicer 612084	25.0	10	100
0	Cable Sets and Adapters 613XXX	1.5	-	-
1	Freon Leak Detector 612086	1.0	10	4
0	Operator's Console 612XXX	80.0	-	-
1	Refrigeration Unit 612115	101.1	17	687
1	GN-2 Service Cart 612XXX	50.0	18	360
1	Vacuum Pumping Unit 612XXX	25.0	17	170
1	Cleaning Kit 612XXX	11.5	23	106
1	Desiccant Drying Oven 614022	27.5	7	77
				6978

4-17

SD 78-SR-0009-2



Rockwell International
Space Division

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Table 4-27. Life Sciences GSE Requirements (Sheet 1 of 16)

GSE REQUIREMENTS-LIFE SCIENCES

Location Site #1 Option A-1/A-3

Quantity	Equipment Name	Unit Cost (\$K)	Invl'm't Time (Days)	Prorated Cost (Flt\$)
1	Transport Dolly, Rack & Floor 612002A	33.0	24	317
1	Vertical Sling Kit, Rack & Floor 612006A	10.5	24	101
0	Horizontal Sling Kit, Rack & Floor 612110A	0	-	-
1	Rack & Floor Shipping Cover 612047A	8.0	18	58
1	Rack & Floor Transport Platform 612048A	24.0	24	230
1	Rack & Floor Support Braces Kit 612049A	2.5	24	24
0	Double Rack Hndlg C/O & Tnspt Kit 612050A	9.0	-	-
0	Single Rack Hndlg C/O & Tnspt Kit 612065A	9.0	-	-
1	Desiccant Canister, Med., Dbl Rack 612068A	9.0	19	68
0	Desiccant Canister, Small, Sngl Rk 612069A	7.0	-	-
0	Active Environ. Control Cart 612071A	33.0	-	-
1	Road Tiedown Kit, U.S. 612106A	10.5	18	76
0	Cargo Lift Trailer, Rack & Floor 614013	0	-	-
0	Adapter Kit Cargo Lift Trailer 614014	0	-	-
1	Transportation Instrumentation 614XXX	20.0	19	152
1	Operators Checkout Console 612XXX	80.0	13	416
	• CDMS Simulator			
	• Ground Pwr Supply (Racks)			
0	Peripheral Checkout Equipment 612XXX	0	-	-
	• Analog Tape Recorder Unit			
	• Strip Chart, Recorder			
0	Optical Alignment Kit 612040	0	-	-
1	Continuity Tester, Electrical 613038	90.5	13	471
1	Grounding/Bonding Tester 613039	31.0	13	161
0	Portable Leak Detection Unit 612080A	0	-	-
0	Freon Leak Detector/Rack Refrig. Freezer 612XXX	0	-	-
0	Vacuum Pumping Unit 612XXX	25.0	-	-
1	Rack Cooling Unit (Support C. O.) 612XXX	50.5	13	263
0	Gas, Bottles, Supply Unit 612XXX	50.0	-	-
0	GN-2 Service Set 614XXX	50.5	-	-
1	Cleaning Kit 612114A	11.5	18	83
0	Desiccant Drying Kit/Oven 614022	0	-	-
1	Human Physiological Simulator	0	-	-
1	Frog Simulator	0	-	-
0	Rat Simulator	0	-	-
0	Oculographic Simulator	0	-	-
0	Mass Spec Analog Data Simulator	0	-	-
0	Rat Temperature Output Simulator	0	-	-
0	Monkey Physiological Simulator	0	-	-
				2420

Table 4-27. Life Sciences GSE Requirements (Sheet 2 of 16)

GSE REQUIREMENTS-LIFE SCIENCES

Location Site #2 Option A-1/A-3

Quantity	Equipment Name	Unit Cost (\$K)	Invl'm't Time (Days)	Prorated Cost (Flt\$)
1	Transport Dolly, Rack & Floor 612002A	33.0	12	158
1	Vertical Sling Kit, Rack & Floor 612006A	10.5	12	50
0	Horizontal Sling Kit, Rack & Floor 612110A	0	-	-
0	Rack & Floor Shipping Cover 612047A	8.0	-	-
0	Rack & Floor Transport Platform 612048A	24.0	-	-
0	Rack & Floor Support Braces Kit 612049A	2.5	-	-
1	Double Rack Hndlg C/O & Tnspt Kit 612050A	9.0	18	65
0	Single Rack Hndlg C/O & Tnspt Kit 612065A	9.0	-	-
1	Desiccant Canister, Med., Dbl Rack 612068A	9.0	13	47
0	Desiccant Canister, Small, Sngl Rk 612069A	7.0	-	-
0	Active Environ. Control Cart 612071A	33.0	-	-
1	Road Tiedown Kit, U.S. 612106A	10.5	13	55
0	Cargo Lift Trailer, Rack & Floor 614013	0	-	-
0	Adapter Kit Cargo Lift Trailer 614014	0	-	-
1	Transportation Instrumentation 614XXX	20.0	13	104
1	Operators Checkout Console 612XXX	80.0	13	416
	• CDMS Simulator			
	• Ground Pwr Supply (Racks)			
0	Peripheral Checkout Equipment 612XXX	0	-	-
	• Analog Tape Recorder Unit			
	• Strip Chart, Recorder			
0	Optical Alignment Kit 612040	0	-	-
1	Continuity Tester, Electrical 613038	90.5	13	471
1	Grounding/Bonding Tester 613039	31.0	13	161
0	Portable Leak Detection Unit 612080A	0	-	-
0	Freon Leak Detector/Rack Refrig. Freezer 612XXX	0	-	-
1	Vacuum Pumping Unit 612XXX	25.0	13	130
1	Rack Cooling Unit (Support C. O.) 612XXX	50.5	13	263
1	Gas, Bottles, Supply Unit 612XXX	50.0	19	380
0	GN-2 Service Set 614XXX	50.0	-	-
1	Cleaning Kit 612114A	11.5	12	55
0	Desiccant Drying Kit/Oven 614022	0	-	-
0	Human Physiological Simulator	0	-	-
0	Frog Simulator	0	-	-
0	Rat Simulator	0	-	-
0	Oculographic Simulator	0	-	-
0	Mass Spec Analog Data Simulator	0	-	-
0	Rat Temperature Output Simulator	0	-	-
0	Monkey Physiological Simulator	0	-	-
				2355

4-18

SD 78-SR-0009-2



Rockwell International
Space Division

Table 4-27. Life Sciences GSE Requirements (Sheet 3 of 16)

GSE REQUIREMENTS-LIFE SCIENCES			Location Site #3 Option A-1/A-3		
Quantity	Equipment Name		Unit Cost (\$K)	Invlm't Time(Days)	Prorated Cost/Flt(\$)
1	Transport Dolly, Rack & Floor	612002A	33.0	10	132
1	Vertical Sling Kit, Rack & Floor	612006A	10.5	10	42
0	Horizontal Sling Kit, Rack & Floor	612110A	0	-	-
0	Rack & Floor Shipping Cover	612047A	8.0	-	-
0	Rack & Floor Transport Platform	612048A	24.0	-	-
0	Rack & Floor Support Braces Kit	612049A	2.5	-	-
0	Double Rack Hndlg C/O & Tnspr Kt	612050A	9.0	-	-
2	Single Rack Hndlg C/O & Tnspr Kt	612065A	9.0	16	116
0	Desiccant Canister, Med., Dbl Rack	612068A	9.0	-	-
2	Desiccant Canister, Small, Sngl Rk	612069A	7.0	11	62
0	Active Environ. Control Cart	612071A	33.0	-	-
1	Road Tiedown Kit, U.S.	612106A	10.5	11	46
0	Cargo Lift Trailer, Rack & Floor	614013	0	-	-
0	Adapter Kit Cargo Lift Trailer	614014	0	-	-
1	Transportation Instrumentation	614XXX	20.0	11	88
1	Operators Checkout Console	612XXX	80.0	11	352
	• CDMS Simulator				
	• Ground Pwr Supply (Racks)				
0	Peripheral Checkout Equipment	612XXX	0	-	-
	• Analog Tape Recorder Unit				
	• Strip Chart, Recorder				
0	Optical Alignment Kit	612040	0	-	-
1	Continuity Tester, Electrical	613038	90.5	11	398
1	Grounding/Bonding Tester	613039	31.0	11	136
0	Portable Leak Detection Unit	612080A	0	-	-
0	Freon Leak Detector(Rack Refrig./Freezer)	612XXX	0	-	-
0	Vacuum Pumping Unit	612XXX	25.0	-	-
1	Rack Cooling Unit (Support C/O)	612XXX	50.5	11	222
0	Gas, Bottles, Supply Unit	612XXX	50.0	-	-
0	GN-2 Service Set	614XXX	50.0	-	-
1	Cleaning Kit	612114A	11.5	10	46
0	Desiccant Drying Kit/Oven	614022	0	-	-
0	Human Physiological Simulator	—	0	-	-
0	Frog Simulator	—	0	-	-
1	Rat Simulator	—	0	-	-
0	Oculographic Simulator	—	0	-	-
0	Mass Spec Analog Data Simulator	—	0	-	-
0	Rat Temperature Output Simulator	—	0	-	-
0	Monkey Physiological Simulator	—	0	-	1640

Table 4-27. Life Sciences GSE Requirements (Sheet 4 of 16)

GSE REQUIREMENTS-LIFE SCIENCES			Location Site #4 Option A-1/A-3		
Quantity	Equipment Name		Unit Cost (\$K)	Invlm't Time(Days)	Prorated Cost/Flt(\$)
1	Transport Dolly, Rack & Floor	612002A	33.0	10	132
1	Vertical Sling Kit, Rack & Floor	612006A	10.5	10	42
0	Horizontal Sling Kit, Rack & Floor	612110A	0	-	-
0	Rack & Floor Shipping Cover	612047A	8.0	-	-
0	Rack & Floor Transport Platform	612048A	24.0	-	-
0	Rack & Floor Support Braces Kit	612049A	2.5	-	-
1	Double Rack Hndlg C/O & Tnspr Kt	612050A	9.0	16	58
0	Single Rack Hndlg C/O & Tnspr Kt	612065A	9.0	-	-
1	Desiccant Canister, Med., Dbl Rack	612068A	9.0	11	40
0	Desiccant Canister, Small, Sngl Rk	612069A	7.0	-	-
0	Active Environ. Control Cart	612071A	33.0	-	-
1	Road Tiedown Kit, U.S.	612106A	10.5	11	46
0	Cargo Lift Trailer, Rack & Floor	614013	0	-	-
0	Adapter Kit Cargo Lift Trailer	614014	0	-	-
1	Transportation Instrumentation	614XXX	20.0	11	88
1	Operators Checkout Console	612XXX	80.0	11	352
	• CDMS Simulator				
	• Ground Pwr Supply (Racks)				
0	Peripheral Checkout Equipment	612XXX	0	-	-
	• Analog Tape Recorder Unit				
	• Strip Chart, Recorder				
0	Optical Alignment Kit	612040	0	-	-
1	Continuity Tester, Electrical	613038	90.5	11	398
1	Grounding/Bonding Tester	613039	31.0	11	136
0	Portable Leak Detection Unit	612080A	0	-	-
0	Freon Leak Detector(Rack Refrig./Freezer)	612XXX	0	-	-
0	Vacuum Pumping Unit	612XXX	25.0	-	-
1	Rack Cooling Unit (Support C/O)	612XXX	50.5	11	222
0	Gas, Bottles, Supply Unit	612XXX	50.0	-	-
1	GN-2 Service Set	614XXX	50.0	11	220
1	Cleaning Kit	612114A	11.5	10	46
0	Desiccant Drying Kit/Oven	614022	0	-	-
0	Human Physiological Simulator	—	0	-	-
0	Frog Simulator	—	0	-	-
0	Rat Simulator	—	0	-	-
0	Oculographic Simulator	—	0	-	-
0	Mass Spec Analog Data Simulator	—	0	-	-
0	Rat Temperature Output Simulator	—	0	-	-
0	Monkey Physiological Simulator	—	0	-	1780

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Table 4-27. Life Sciences GSE Requirements (Sheet 5 of 16)

GSE REQUIREMENTS-LIFE SCIENCES			Location Site #5 Option A-1/A-3		
Quantity	Equipment Name	Unit Cost (\$K)	Invlvm't Time(Days)	Prorated Cost/Fit(\$)	
1	Transport Dolly, Rack & Floor 612002A	33.0	7	92	
1	Vertical Sling Kit, Rack & Floor 612006A	10.5	7	29	
0	Horizontal Sling Kit, Rack & Floor 612110A	0	-	-	
0	Rack & Floor Shipping Cover 612047A	8.0	-	-	
0	Rack & Floor Transport Platform 612048A	24.0	-	-	
0	Rack & Floor Support Braces Kit 612049A	2.5	-	-	
1	Double Rack Hndlg C/O & Tnspt Kt 612050A	9.0	13	47	
0	Single Rack Hndlg C/O & Tnspt Kt 612065A	9.0	-	-	
1	Desiccant Canister, Med., Dbl Rack 612068A	9.0	8	29	
0	Desiccant Canister, Small, Sngl Rk 612069A	7.0	-	-	
0	Active Environ. Control Cart 612071A	33.0	-	-	
1	Road Tiedown Kit, U.S. 612106A	10.5	8	34	
0	Cargo Lift Trailer, Rack & Floor 614013	0	-	-	
0	Adapter Kit Cargo Lift Trailer 614014	0	-	-	
1	Transportation Instrumentation 614XXX	20.0	8	64	
1	Operators Checkout Console 612XXX	80.0	8	256	
	• CDMS Simulator				
	• Ground Pwr Supply (Racks)				
0	Peripheral Checkout Equipment 612XXX	0	-	-	
	• Analog Tape Recorder Unit				
	• Strip Chart, Recorder				
0	Optical Alignment Kit 612040	0	-	-	
1	Continuity Tester, Electrical 613003	90.5	8	290	
1	Grounding/Bonding Tester 613039	31.0	8	99	
0	Portable Leak Detection Unit 612080A	0	-	-	
0	Freon Leak Detector(Rack Refrig/Freezer 612XXX	0	-	-	
1	Vacuum Pumping Unit 612XXX	25.0	8	80	
1	Rack Cooling Unit (Support C.O) 612XXX	50.5	8	162	
0	Gas, Bottles, Supply Unit 612XXX	50.0	-	-	
0	GN-2 Service Set 614XXX	50.0	-	-	
1	Cleaning Kit 612114A	11.5	7	32	
0	Desiccant Drying Kit/Oven 614022	0	-	-	
0	Human Physiological Simulator	0	-	-	
0	Frog Simulator	0	-	-	
0	Rat Simulator	0	-	-	
0	Oculographic Simulator	0	-	-	
0	Mass Spec Analog Data Simulator	0	-	-	
0	Rat Temperature Output Simulator	0	-	-	
0	Monkey Physiological Simulator	0	-	1214	

Table 4-27. Life Sciences GSE Requirements (Sheet 6 of 16)

GSE REQUIREMENTS-LIFE SCIENCES			Location Site #6 Option A-1/A-3		
Quantity	Equipment Name	Unit Cost (\$K)	Invlvm't Time(Days)	Prorated Cost/Fit(\$)	
1	Transport Dolly, Rack & Floor 612002A	33.0	11	145	
1	Vertical Sling Kit, Rack & Floor 612006A	10.5	11	46	
0	Horizontal Sling Kit, Rack & Floor 612110A	0	-	-	
0	Rack & Floor Shipping Cover 612047A	8.0	-	-	
0	Rack & Floor Transport Platform 612048A	24.0	-	-	
0	Rack & Floor Support Braces Kit 612049A	2.5	-	-	
1	Double Rack Hndlg C/O & Tnspt Kt 612050A	9.0	17	61	
0	Single Rack Hndlg C/O & Tnspt Kt 612065A	9.0	-	-	
1	Desiccant Canister, Med., Dbl Rack 612068A	9.0	12	43	
0	Desiccant Canister, Small, Sngl Rk 612069A	7.0	-	-	
0	Active Environ. Control Cart 612071A	33.0	-	-	
1	Road Tiedown Kit, U.S. 612106A	10.5	12	50	
0	Cargo Lift Trailer, Rack & Floor 614013	0	-	-	
0	Adapter Kit Cargo Lift Trailer 614014	0	-	-	
1	Transportation Instrumentation 614XXX	20.0	12	96	
1	Operators Checkout Console 612XXX	80.0	12	384	
	• CDMS Simulator				
	• Ground Pwr Supply (Racks)				
0	Peripheral Checkout Equipment 612XXX	0	-	-	
	• Analog Tape Recorder Unit				
	• Strip Chart, Recorder				
0	Optical Alignment Kit 612040	0	-	-	
1	Continuity Tester, Electrical 613003	90.5	12	434	
1	Grounding/Bonding Tester 613039	31.0	12	149	
0	Portable Leak Detection Unit 612080A	0	-	-	
0	Freon Leak Detector(Rack Refrig/Freezer 612XXX	0	-	-	
0	Vacuum Pumping Unit 612XXX	25.0	-	-	
1	Rack Cooling Unit (Support C.O) 612XXX	50.5	12	242	
1	Gas, Bottles, Supply Unit 612XXX	50.0	11	220	
0	GN-2 Service Set 614XXX	50.0	-	-	
1	Cleaning Kit 612114A	11.5	11	51	
0	Desiccant Drying Kit/Oven 614022	0	-	-	
0	Human Physiological Simulator	0	-	-	
0	Frog Simulator	0	-	-	
0	Rat Simulator	0	-	-	
1	Oculographic Simulator	0	-	-	
0	Mass Spec Analog Data Simulator	0	-	-	
0	Rat Temperature Output Simulator	0	-	-	
0	Monkey Physiological Simulator	0	-	1922	

4-20

SD 78-SR-0009-2

Table 4-27. Life Sciences GSE Requirements (Sheet 7 of 16)

GSE REQUIREMENTS-LIFE SCIENCES			Location Site #7 Option A-1/A-3		
Quantity	Equipment Name	Unit Cost (\$K)	Invol'm't Time(Days)	Prorated Cost/Fit(\$)	
1	Transport Dolly, Rack & Floor 612002A	33.0	12	158	
1	Vertical Sling Kit, Rack & Floor 612006A	10.5	12	50	
0	Horizontal Sling Kit, Rack & Floor 612110A	0	-	-	
0	Rack & Floor Shipping Cover 612047A	8.0	-	-	
0	Rack & Floor Transport Platform 612048A	24.0	-	-	
0	Rack & Floor Support Braces Kit 612049A	2.5	-	-	
1	Double Rack Hndlg C/O & Tnspt Kt 612050A	9.0	18	65	
0	Single Rack Hndlg C/O & Tnspt Kt 612065A	9.0	-	-	
1	Desiccant Canister, Med., Dbl Rack 612068A	9.0	13	47	
0	Desiccant Canister, Small, Sngl Rk 612069A	7.0	-	-	
0	Active Environ. Control Cart 612071A	33.0	-	-	
1	Road Tiedown Kit, U.S. 612106A	10.5	13	55	
0	Cargo Lift Trailer, Rack & Floor 614013	0	-	-	
0	Adapter Kit Cargo Lift Trailer 614014	0	-	-	
1	Transportation Instrumentation 614XXX	20.0	13	104	
1	Operators Checkout Console 612XXX	80.0	13	416	
	• CDMS Simulator				
	• Ground Pwr Supply (Racks)				
0	Peripheral Checkout Equipment 612XXX	0	-	-	
	• Analog Tape Recorder Unit				
	• Strip Chart, Recorder				
0	Optical Alignment Kit 612040	0	-	-	
1	Continuity Tester, Electrical 613038	90.5	13	471	
1	Grounding, Bonding Tester 613039	31.0	13	161	
0	Portable Leak Detection Unit 612080A	0	-	-	
0	Freon Leak Detector(Rack Refrig/Freezer 612XXX	0	-	-	
0	Vacuum Pumping Unit 612XXX	25.0	-	-	
1	Rack Cooling Unit (Support C/O) 612XXX	50.5	13	263	
1	Gas, Bottles, Supply Unit 612XXX	50.0	12	240	
1	GN-2 Service Set 614XXX	50.0	13	260	
1	Cleaning Kit 612114A	11.5	12	55	
0	Desiccant Drying Kit Oven 614022	0	-	-	
0	Human Physiologist Simulator	0	-	-	
0	Frog Simulator	0	-	-	
0	Rat Simulator	0	-	-	
0	Oculographic Simulator	0	-	-	
1	Mass Spec Analog Data Simulator	0	-	-	
1	Rat Temperature Output Simulator	0	-	-	
0	Monkey Physiological Simulator	0	-	-	
				2345	

Table 4-27. Life Sciences GSE Requirements (Sheet 8 of 16)

GSE REQUIREMENTS-LIFE SCIENCES			Location Site #8	Option A-1/A-3
Quantity	Equipment Name	Unit Cost (\$K)	Involvement Time(Days)	Prorated Cost/Fit(\$)
1	Transport Dolly, Rack & Floor 612002A	33.0	23	304
1	Vertical Sling Kit, Rack & Floor 612006A	10.5	20	84
0	Horizontal Sling Kit, Rack & Floor 612110A	0	-	-
1	Rack & Floor Shipping Cover 612047A	8.0	26	83
1	Rack & Floor Transport Platform 612048A	24.0	28	269
1	Rack & Floor Support Braces Kit 612049A	2.5	27	27
0	Double Rack Hndlg C/O & Tnspt Kt 612050A	9.0	-	-
0	Single Rack Hndlg C/O & Tnspt Kt 612065A	9.0	-	-
0	Desiccant Canister, Med., Dbl Rack 612068A	9.0	-	-
2	Desiccant Canister, Small, Sngl Rk 612069A	7.0	27	151
0	Active Environ. Control Cart 612071A	33.0	-	-
1	Road Tiedown Kit, U.S. 612106A	10.5	27	113
0	Cargo Lift Trailer, Rack & Floor 614013	0	-	-
0	Adapter Kit Cargo Lift Trailer 614014	0	-	-
1	Transportation Instrumentation 614XXX	20.0	27	216
1	Operators Checkout Console 612XXX	80.0	21	672
	• CDMS Simulator			
	• Ground Pwr Supply (Racks)			
0	Peripheral Checkout Equipment 612XXX	0	-	-
	• Analog Tape Recorder Unit			
	• Strip Chart, Recorder			
0	Optical Alignment Kit 612040	0	-	-
1	Continuity Tester, Electrical 613038	90.5	21	760
1	Grounding, Bonding Tester 613039	31.0	21	260
0	Portable Leak Detection Unit 612080A	0	-	-
0	Freon Leak Detector(Rack Refrig/Freezer 612XXX	0	-	-
1	Vacuum Pumping Unit 612XXX	25.0	21	210
1	Rack Cooling Unit (Support C. O) 612XXX	50.5	21	424
0	Gas, Bottles, Supply Unit 612XXX	50.0	-	-
0	GN-2 Service Set 614XXX	50.0	-	-
1	Cleaning Kit 612114A	11.5	20	92
0	Desiccant Drying Kit/Oven 614022	0	-	-
0	Human Physiological Simulator	0	-	-
0	Frog Simulator	0	-	-
0	Rat Simulator	0	-	-
0	Oculographic Simulator	0	-	-
0	Mass Spec Analog Data Simulator	0	-	-
0	Rat Temperature Output Simulator	0	-	-
1	Monkey Physiological Simulator	0	-	-
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4-21

SD 78-SR-0009-2

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Table 4-27. Life Sciences GSE Requirements (Sheet 9 of 16)

GSE REQUIREMENTS-LIFE SCIENCES					Location	Mini-Center	Option	A-3 Delta *
Quantity	Equipment Name	Unit Cost (\$K)	Invlvm't Time(Days)	Prorated Cost/Ftr(\$)				
1	Transport Dolly, Rack & Floor	612002A	33.0	7	92			
0	Vertical Sling Kit, Rack & Floor	612006A	10.5	-	-			
0	Horizontal Sling Kit, Rack & Floor	612110A	0	-	-			
1	Rack & Floor Shipping Cover	612047A	8.0	1	3			
1	Rack & Floor Transport Platform	612048A	24.0	1	10			
1	Rack & Floor Support Braces Kit	612049A	2.5	7	7			
0	Double Rack Hndlg C/O & Tnspt Kt	612050A	9.0	-	-			
0	Single Rack Hndlg C/O & Tnspt Kt	612065A	9.0	-	-			
6	Desiccant Canister, Med., Dbl Rack	612068A	9.0	7	151			
4	Desiccant Canister, Small, Sngl Rk	612069A	7.0	7	78			
1	Active Environ. Control Cart	612071A	33.0	7	92			
1	Road Tiedown Kit, U.S.	612106A	10.5	1	4			
0	Cargo Lift Trailer, Rack & Floor	614013	0	-	-			
0	Adapter Kit Cargo Lift Trailer	614014	0	-	-			
1	Transportation Instrumentation	614XXX	20.0	1	8			
1	Operators Checkout Console	612XXX	80.0	0	192			
	• CDMS Simulator							
	• Ground Pwr Supply (Racks)							
0	Peripheral Checkout Equipment	612XXX	0	-	-			
	• Analog Tape Recorder Unit							
	• Strip Chart, Recorder							
0	Optical Alignment Kit	612040	0	-	-			
1	Continuity Tester, Electrical	613038	90.5	7	253			
1	Grounding/Bonding Tester	613039	31.0	7	87			
0	Portable Leak Detection Unit	612080A	0	-	-			
0	Freon Leak Detector(Rack Refrig/Freezer)	612XXX	0	-	-			
1	Vacuum Pumping Unit	612XXX	25.0	6	60			
1	Rack Cooling Unit (Support C/O)	612XXX	50.5	6	121			
1	Gas, Bottles, Supply Unit	612XXX	50.0	6	120			
1	GN-2 Service Set	614XXX	50.0	6	120			
1	Cleaning Kit	612114A	11.5	7	32			
0	Desiccant Drying Kit/Oven	614022	0	-	-			
1	Human Physiological Simulator	—	0	-	-			
1	Frog Simulator	—	0	-	-			
1	Rat Simulator	—	0	-	-			
1	Oculographic Simulator	—	0	-	-			
1	Mass Spec Analog Data Simulator	—	0	-	-			
1	Rat Temperature Output Simulator	—	0	-	-			
1	Monkey Physiological Simulator	—	0	-	-			
					1430			

* These are the requirements for processing flow blocks 7, 8 and 9 as performed at KSC after Level IV activities at the 8 Distributed Sites.

Table 4-27. Life Sciences GSE Requirements (Sheet 10 of 16)

GSE REQUIREMENTS-LIFE SCIENCES					Location	Lead Ctr	Option	B-1
Quantity	Equipment Name	Unit Cost (\$K)	Invlvm't Time(Days)	Prorated Cost/Ftr(\$)				
1	Transport Dolly, Rack & Floor	612002A	33.0	31	409			
1	Vertical Sling Kit, Rack & Floor	612006A	10.5	28	118			
0	Horizontal Sling Kit, Rack & Floor	612110A	0	-	-			
1	Rack & Floor Shipping Cover	612047A	8.0	25	80			
1	Rack & Floor Transport Platform	612048A	24.0	31	298			
1	Rack & Floor Support Braces Kit	612049A	2.5	31	31			
0	Double Rack Hndlg C/O & Tnspt Kt	612050A	9.0	-	-			
0	Single Rack Hndlg C/O & Tnspt Kt	612065A	9.0	-	-			
6	Desiccant Canister, Med., Dbl Rack	612068A	9.0	26	562			
4	Desiccant Canister, Small, Sngl Rk	612069A	7.0	26	291			
1	Active Environ. Control Cart	612071A	33.0	26	343			
1	Road Tiedown Kit, U.S.	612106A	10.5	25	105			
0	Cargo Lift Trailer, Rack & Floor	614013	0	-	-			
0	Adapter Kit Cargo Lift Trailer	614014	0	-	-			
1	Transportation Instrumentation	614XXX	20.0	26	208			
1	Operators Checkout Console	612XXX	80.0	20	640			
	• CDMS Simulator							
	• Ground Pwr Supply (Racks)							
0	Peripheral Checkout Equipment	612XXX	0	-	-			
	• Analog Tape Recorder Unit							
	• Strip Chart, Recorder							
0	Optical Alignment Kit	612040	0	-	-			
1	Continuity Tester, Electrical	613038	90.5	20	724			
1	Grounding/Bonding Tester	613039	31.0	20	248			
0	Portable Leak Detection Unit	612080A	0	-	-			
0	Freon Leak Detector(Rack Refrig/Freezer)	612XXX	0	-	-			
1	Vacuum Pumping Unit	612XXX	25.0	20	200			
1	Rack Cooling Unit (Support C/O)	612XXX	50.5	20	404			
1	Gas, Bottles, Supply Unit	612XXX	50.0	28	560			
1	GN-2 Service Set	614XXX	50.0	20	400			
1	Cleaning Kit	612114A	11.5	25	115			
0	Desiccant Drying Kit/Oven	614022	0	-	-			
1	Human Physiological Simulator	—	0	-	-			
1	Frog Simulator	—	0	-	-			
1	Rat Simulator	—	0	-	-			
1	Oculographic Simulator	—	0	-	-			
1	Mass Spec Analog Data Simulator	—	0	-	-			
1	Rat Temperature Output Simulator	—	0	-	-			
1	Monkey Physiological Simulator	—	0	-	-			
					5736			

Table 4-27. Life Sciences GSE Requirements (Sheet 12 of 16)

GSE REQUIREMENTS-LIFE SCIENCES					
Location Lead Ctr Option B-4					
Quantity	Equipment Name	Unit Cost (\$K)	Invlm't Time(Days)	Prorated Cost/Ft(\$)	
1	Transport Dolly, Rack & Floor	612002A	33.0	40	521
1	Vertical Sling Kit, Rack & Floor	612006A	10.5	32	134
0	Horizontal Sling Kit, Rack & Floor	612110A	0	-	-
1	Rack & Floor Shipping Cover	612047A	8.0	30	96
1	Rack & Floor Transport Platform	612048A	24.0	36	346
1	Rack & Floor Support Braces Kit	612049A	2.5	40	40
0	Double Rack Hndlg C/O & Tnspt Kt	612050A	9.0	-	-
0	Single Rack Hndlg C/O & Tnspt Kt	612065A	9.0	-	-
6	Desiccant Canister, Med., Dbl Rack	612068A	9.0	35	745
4	Desiccant Canister, Small, Sngl Rk	612069A	7.0	35	386
1	Active Environ. Control Cart	612071A	33.0	35	455
1	Road Tiedown Kit, U.S.	612106A	10.5	30	126
0	Cargo Lift Trailer, Rack & Floor	614013	0	-	-
0	Adapter Kit Cargo Lift Trailer	614014	0	-	-
1	Transportation Instrumentation	614XXX	20.0	31	248
1	Operators Checkout Console	612XXX	80.0	29	912
	• CDMS Simulator				
	• Ground Pwr Supply (Racks)				
0	Peripheral Checkout Equipment	612XXX	0	-	-
	• Analog Tape Recorder Unit				
	• Strip Chart, Recorder				
0	Optical Alignment Kit	612040	0	-	-
1	Continuity Tester, Electrical	613038	90.5	29	1032
1	Grounding/Bonding Tester	613039	31.0	29	354
0	Portable Leak Detection Unit	612080A	0	-	-
0	Freon Leak Detector/Rack Refrig. Freezer	612XXX	0	-	-
1	Vacuum Pumping Unit	612XXX	25.0	29	285
1	Rack Cooling Unit (Support C/O)	612XXX	50.5	29	576
1	Gas, Bottles, Supply Unit	612XXX	50.0	37	730
1	GN-2 Service Set	614XXX	50.0	29	570
1	Cleaning Kit	612114A	11.5	34	154
0	Desiccant Drying Kit/Oven	614022	0	-	-
1	Human Physiological Simulator	—	0	-	-
1	Frog Simulator	—	0	-	-
1	Rat Simulator	—	0	-	-
1	Oculographic Simulator	—	0	-	-
1	Mass Spec Analog Data Simulator	—	0	-	-
1	Rat Temperature Output Simulator	—	0	-	-
1	Monkey Physiological Simulator	—	0	-	7710

Table 4-27. Life Sciences GSE Requirements (Sheet 11 of 16)

GSE REQUIREMENTS-LIFE SCIENCES					
Location Lead Ctr Option B-3					
Quantity	Equipment Name	Unit Cost (\$K)	Invlm't Time(Days)	Prorated Cost/Ft(\$)	
1	Transport Dolly, Rack & Floor	612002A	33.0	38	495
1	Vertical Sling Kit, Rack & Floor	612006A	10.5	28	118
0	Horizontal Sling Kit, Rack & Floor	612110A	0	-	-
1	Rack & Floor Shipping Cover	612047A	8.0	26	83
1	Rack & Floor Transport Platform	612048A	24.0	32	308
1	Rack & Floor Support Braces Kit	612049A	2.5	38	38
0	Double Rack Hndlg C/O & Tnspt Kt	612050A	9.0	-	-
0	Single Rack Hndlg C/O & Tnspt Kt	612065A	9.0	-	-
6	Desiccant Canister, Med., Dbl Rack	612068A	9.0	33	702
4	Desiccant Canister, Small, Sngl Rk	612069A	7.0	33	364
1	Active Environ. Control Cart	612071A	33.0	33	429
1	Road Tiedown Kit, U.S.	612106A	10.5	26	109
0	Cargo Lift Trailer, Rack & Floor	614013	0	-	-
0	Adapter Kit Cargo Lift Trailer	614014	0	-	-
1	Transportation Instrumentation	614XXX	20.0	27	216
1	Operators Checkout Console	612XXX	80.0	26	816
	• CDMS Simulator				
	• Ground Pwr Supply (Racks)				
0	Peripheral Checkout Equipment	612XXX	0	-	-
	• Analog Tape Recorder Unit				
	• Strip Chart, Recorder				
0	Optical Alignment Kit	612040	0	-	-
1	Continuity Tester, Electrical	613038	90.5	27	959
1	Grounding/Bonding Tester	613039	31.0	27	329
0	Portable Leak Detection Unit	612080A	0	-	-
0	Freon Leak Detector/Rack Refrig. Freezer	612XXX	0	-	-
1	Vacuum Pumping Unit	612XXX	25.0	26	255
1	Rack Cooling Unit (Support C/O)	612XXX	50.5	26	515
1	Gas, Bottles, Supply Unit	612XXX	50.0	34	670
1	GN-2 Service Set	614XXX	50.0	26	510
1	Cleaning Kit	612114A	11.5	32	145
0	Desiccant Drying Kit/Oven	614022	0	-	-
1	Human Physiological Simulator	—	0	-	-
1	Frog Simulator	—	0	-	-
1	Rat Simulator	—	0	-	-
1	Oculographic Simulator	—	0	-	-
1	Mass Spec Analog Data Simulator	—	0	-	-
1	Rat Temperature Output Simulator	—	0	-	-
1	Monkey Physiological Simulator	—	0	-	7001

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4-23

SD 78-SR-0009-2

Table 4-27. Life Sciences GSE Requirements (Sheet 13 of 16)

GSE REQUIREMENTS-LIFE SCIENCES					Location	Lead	Ctrl	Option	B-5
Quantity	Equipment Name		Unit Cost (\$K)	Invlvm't Time(Days)	Prorate Cost/Flt(\$)				
1	Transport Dolly, Rack & Floor	612002A	33.0	43	568				
1	Vertical Sling Kit, Rack & Floor	612006A	10.5	35	147				
0	Horizontal Sling Kit, Rack & Floor	612110A	0	-	-				
1	Rack & Floor Shipping Cover	612047A	8.0	33	106				
1	Rack & Floor Transport Platform	612048A	24.0	39	374				
1	Rack & Floor Support Braces Kit	612049A	2.5	43	43				
0	Double Rack Hndlg C/O & Tnspt Kt	612050A	9.0	-	-				
0	Single Rack Hndlg C/O & Tnspt Kt	612065A	9.0	-	-				
6	Desiccant Canister, Med., Dbl Rack	612068A	9.0	38	821				
4	Desiccant Canister, Small, Sngl Rk	612069A	7.0	38	426				
1	Active Environ. Control Cart	612071A	33.0	38	502				
1	Road Tiedown Kit, U.S.	612106A	10.5	33	139				
0	Cargo Lift Trailer, Rack & Floor	614013	0	-	-				
0	Adapter Kit Cargo Lift Trailer	614014	0	-	-				
1	Transportation Instrumentation	614XXX	20.0	34	272				
1	Operators Checkout Console	612XXX	80.0	32	1024				
	• CDMS Simulator								
	• Ground Pwr Supply (Racks)								
0	Peripheral Checkout Equipment	612XXX	0	-	-				
	• Analog Tape Recorder Unit								
	• Strip Chart, Recorder								
0	Optical Alignment Kit	612040	0	-	-				
1	Continuity Tester, Electrical	613033	90.5	32	1158				
1	Grounding/Bonding Tester	613039	31.0	32	397				
0	Portable Leak Detection Unit	612080A	0	-	-				
0	Freon Leak Detector(Rack Refrig/Freezer)	612XXX	0	-	-				
1	Vacuum Pumping Unit	612XXX	25.0	32	320				
1	Rack Cooling Unit (Support C. O)	612XXX	50.5	32	646				
1	Gas, Bottles, Supply Unit	612XXX	50.0	40	800				
1	GN-2 Service Set	614XXX	50.0	32	640				
1	Cleaning Kit	612114A	11.5	37	170				
0	Desiccant Drying Kit/Oven	614022	0	-	-				
1	Human Physiological Simulator	—	0	-	-				
1	Frog Simulator	—	0	-	-				
1	Rat Simulator	—	0	-	-				
1	Oculographic Simulator	—	0	-	-				
1	Mass Spec Analog Data Simulator	—	0	-	-				
1	Rat Temperature Output Simulator	—	0	-	-				
1	Monkey Physiological Simulator	—	0	-	-				
					8553				

Table 4-27. Life Sciences GSE Requirements (Sheet 14 of 16)

GSE REQUIREMENTS-LIFE SCIENCES					Location	KSC	Option	C-1
Quantity	Equipment Name		Unit Cost (\$K)	Invlvm't Time(Days)	Prorate Cost/Flt(\$)			
1	Transport Dolly, Rack & Floor	612002A	33.0	23	304			
1	Vertical Sling Kit, Rack & Floor	612006A	10.5	26	109			
0	Horizontal Sling Kit, Rack & Floor	612110A	0	-	-			
1	Rack & Floor Shipping Cover	612047A	8.0	17	54			
1	Rack & Floor Transport Platform	612048A	24.0	23	221			
1	Rack & Floor Support Braces Kit	612049A	2.5	23	23			
0	Double Rack Hndlg C/O & Tnspt Kt	612050A	9.0	-	-			
0	Single Rack Hndlg C/O & Tnspt Kt	612065A	9.0	-	-			
6	Desiccant Canister, Med., Dbl Rack	612068A	9.0	18	389			
4	Desiccant Canister, Small, Sngl Rk	612069A	7.0	18	202			
1	Active Environ. Control Cart	612071A	33.0	18	238			
1	Road Tiedown Kit, U.S.	612106A	10.5	17	71			
0	Cargo Lift Trailer, Rack & Floor	614013	0	-	-			
0	Adapter Kit Cargo Lift Trailer	614014	0	-	-			
1	Transportation Instrumentation	614XXX	20.0	18	144			
1	Operators Checkout Console	612XXX	80.0	18	576			
	• CDMS Simulator							
	• Ground Pwr Supply (Racks)							
0	Peripheral Checkout Equipment	612XXX	0	-	-			
	• Analog Tape Recorder Unit							
	• Strip Chart, Recorder							
0	Optical Alignment Kit	612040	0	-	-			
1	Continuity Tester, Electrical	613038	90.5	18	652			
1	Grounding/Bonding Tester	613039	31.0	18	223			
0	Portable Leak Detection Unit	612080A	0	-	-			
0	Freon Leak Detector(Rack Refrig/Freezer)	612XXX	0	-	-			
1	Vacuum Pumping Unit	612XXX	25.0	18	180			
1	Rack Cooling Unit (Support C. O)	612XXX	50.5	18	364			
1	Gas, Bottles, Supply Unit	612XXX	50.0	26	520			
1	GN-2 Service Set	614XXX	50.0	18	360			
1	Cleaning Kit	612114A	11.5	23	106			
0	Desiccant Drying Kit/Oven	614022	0	-	-			
1	Human Physiological Simulator	—	0	-	-			
1	Frog Simulator	—	0	-	-			
1	Rat Simulator	—	0	-	-			
1	Oculographic Simulator	—	0	-	-			
1	Mass Spec Analog Data Simulator	—	0	-	-			
1	Rat Temperature Output Simulator	—	0	-	-			
1	Monkey Physiological Simulator	—	0	-	-			
					4736			

Table 4-27. Life Sciences GSE Requirements (Sheet 16 of 16)

GSE REQUIREMENTS-LIFE SCIENCES

Location KSC Option C-4

Quantity	Equipment Name	Unit Cost (\$K)	Involmnt Time(Days)	Prorated Cost/Flt(\$)
1	Transport Dolly, Rack & Floor 612002A	33.0	27	356
1	Vertical Sling Kit, Rack & Floor 612006A	10.5	30	126
0	Horizontal Sling Kit, Rack & Floor 612110A	0	-	-
1	Rack & Floor Shipping Cover 612047A	8.0	21	67
1	Rack & Floor Transport Platform 612048A	24.0	27	259
1	Rack & Floor Support Braces Kit 612049A	2.5	27	27
0	Double Rack Hndlg C/O & Tnsor Kt 612050A	9.0	-	-
0	Single Rack Hndlg C/O & Tnspr Kt 612065A	9.0	-	-
6	Desiccant Canister, Med., Dbl Rack 612068A	9.0	22	475
4	Desiccant Canister, Small, Sngl Rk 612069A	7.0	22	246
1	Active Environ. Control Cart 612071A	33.0	22	290
1	Road Tiedown Kit, U.S. 612106A	10.5	21	88
0	Cargo Lift Trailer, Rack & Floor 614013	0	-	-
0	Adapter Kit Cargo Lift Trailer 614014	0	-	-
1	Transportation Instrumentation 614XXX	20.0	22	176
1	Operators Checkout Console 612XXX	80.0	22	704
	• CDMS Simulator			
	• Ground Pwr Supply (Racks)			
0	Peripheral Checkout Equipment 612XXX	0	-	-
	• Analog Tape Recorder Unit			
	• Strip Chart, Recorder			
0	Optical Alignment Kit 612040	0	-	-
1	Continuity Tester, Electrical 613038	90.5	22	796
1	Grounding, Bonding Tester 613039	31.0	22	273
0	Portable Leak Detection Unit 612080A	0	-	-
0	Freon Leak Detector(Rack Refrig./Freezer 612XXX	0	-	-
1	Vacuum Pumping Unit 612XXX	25.0	22	220
1	Rack Cooling Unit (Support C 'O) 612XXX	50.5	22	444
1	Gas, Bottles, Supply Unit 612XXX	50.0	30	600
1	GN-2 Service Set 614XXX	50.0	22	440
1	Cleaning Kit 612114A	11.5	27	124
0	Desiccant Drying Kit/Oven 614022	0	-	-
1	Human Physiological Simulator	0	-	-
1	Frog Simulator	0	-	-
1	Rat Simulator	0	-	-
1	Oculographic Simulator	0	-	-
1	Mass Spec Analog Data Simulator	0	-	-
1	Rat Temperature Output Simulator	0	-	-
1	Monkey Physiological Simulator	0	-	-
				5711

Table 4-27. Life Sciences GSE Requirements (Sheet 15 of 16)

GSE REQUIREMENTS-LIFE SCIENCES

Location KSC Option C-3

Quantity	Equipment Name	Unit Cost (\$K)	Involmnt Time(Days)	Prorated Cost/Flt(\$)
1	Transport Dolly, Rack & Floor 612002A	33.0	31	390
1	Vertical Sling Kit, Rack & Floor 612006A	10.5	28	118
0	Horizontal Sling Kit, Rack & Floor 612110A	0	-	-
1	Rack & Floor Shipping Cover 612047A	8.0	25	57
1	Rack & Floor Transport Platform 612048A	24.0	31	231
1	Rack & Floor Support Braces Kit 612049A	2.5	31	30
0	Double Rack Hndlg C/O & Tnsor Kt 612050A	9.0	-	-
0	Single Rack Hndlg C/O & Tnspr Kt 612065A	9.0	-	-
6	Desiccant Canister, Med., Dbl Rack 612068A	9.0	26	529
4	Desiccant Canister, Small, Sngl Rk 612069A	7.0	26	275
1	Active Environ. Control Cart 612071A	33.0	26	324
1	Road Tiedown Kit, U.S. 612106A	10.5	25	75
0	Cargo Lift Trailer, Rack & Floor 614013	0	-	-
0	Adapter Kit Cargo Lift Trailer 614014	0	-	-
1	Transportation Instrumentation 614XXX	20.0	26	152
1	Operators Checkout Console 612XXX	80.0	26	752
	• CDMS Simulator			
	• Ground Pwr Supply (Racks)			
0	Peripheral Checkout Equipment 612XXX	0	-	-
	• Analog Tape Recorder Unit			
	• Strip Chart, Recorder			
0	Optical Alignment Kit 612040	0	-	-
1	Continuity Tester, Electrical 613038	90.5	26	887
1	Grounding, Bonding Tester 613039	31.0	26	305
0	Portable Leak Detection Unit 612080A	0	-	-
0	Freon Leak Detector(Rack Refrig./Freezer 612XXX	0	-	-
1	Vacuum Pumping Unit 612XXX	25.0	26	235
1	Rack Cooling Unit (Support C 'O) 612XXX	50.5	26	475
1	Gas, Bottles, Supply Unit 612XXX	50.0	34	630
1	GN-2 Service Set 614XXX	50.0	26	470
1	Cleaning Kit 612114A	11.5	31	136
0	Desiccant Drying Kit/Oven 614022	0	-	-
1	Human Physiological Simulator	0	-	-
1	Frog Simulator	0	-	-
1	Rat Simulator	0	-	-
1	Oculographic Simulator	0	-	-
1	Mass Spec Analog Data Simulator	0	-	-
1	Rat Temperature Output Simulator	0	-	-
1	Monkey Physiological Simulator	0	-	-
				6071

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Table 4-28. ATL GSE Requirements (Sheet 1 of 6)

Location Site #1 Option A-1					
Quantity	Equipment Name	Unit Cost (\$K)	Invlvm't Time(Days)	Prorated Cost/Fit(\$)	
0	Double Rack Handling Kit 613050	9.0	-	-	
1	Vertical Sling Kit 612006A	10.5	28	118	
1	Feed Thru Prot. Covers 612008	3.0	23	27	
1	Pallet Seg. Floor Covers 612010	3.5	28	39	
1	Pallet Segment Support 612013	47.0	31	583	
1	Rack/Floor Shipping Cover 612047	8.0	26	83	
1	Rack/Floor Transport Platform 612048	1.0	31	12	
1	Rack/Floor Support Braces 612049	2.5	31	31	
1	Pallet Cover 612059	12.5	26	130	
1	Pallet Platform 612060	24.0	26	250	
1	Desiccant Canister Large 612067	11.5	26	120	
1	Desiccant Canister Medium 612068	9.0	26	94	
1	Active Environment Cart 612071A	33.0	26	346	
1	Road Tiedown Kit 612106	10.5	26	109	
1	Horizontal Sling Kit 612110	53.5	27	578	
4	Trunnion Handling Fittings 612113	1.0	27	43	
1	Refrigeration Unit 612115	101.1	20	808	
1	Rack Cooling Unit 612XXX	50.5	20	404	
1	Cleaning Kit 612114	11.5	20	92	
1	Desiccant Drying Oven 614002	27.5	20	220	
1	Grounding/Bonding Tester 613039	31.0	20	248	
1	Cable Sets and Adapters	-	-	-	
1	Portable Leak Detector 612080	2.5	20	20	
1	Freon Servicer 612084	25.0	20	200	
1	Freon Leak Detector 612086	1.0	20	8	
1	Optical Alignment Kit 612040	6.0	20	48	
1	Transport Instrumentation 614XXX	20.0	23	184	
1	Operator's Console 612XXX	80.0	20	640	
0	Optical Bench Support Cart				
0	Inert Gas Cart				
0	FSS Holding Jig and Cover				
0	Broad Band Illuminator				
0	Antenna Support Cart				
				5432	

Table 4-28. ATL GSE Requirements (Sheet 2 of 6)

Location Site #2 Option A-1					
Quantity	Equipment Name	Unit Cost (\$K)	Invlvm't Time(Days)	Prorated Cost/Fit(\$)	
1	Double Rack Handling Kit 613050	9.0	17	61	
0	Vertical Sling Kit 612006A	10.5	-	-	
0	Feed Thru Prot. Covers 612008	3.0	-	-	
0	Pallet Seg. Floor Covers 612010	3.5	-	-	
0	Pallet Segment Support 612013	47.0	-	-	
0	Rack/Floor Shipping Cover 612047	8.0	-	-	
0	Rack/Floor Transport Platform 612048	1.0	-	-	
0	Rack/Floor Support Braces 612049	2.5	-	-	
0	Pallet Cover 612059	12.5	-	-	
0	Pallet Platform 612060	24.0	-	-	
0	Desiccant Canister Large 612067	11.5	-	-	
0	Desiccant Canister Medium 612068	9.0	17	61	
0	Active Environment Cart 612071A	33.0	-	-	
0	Road Tiedown Kit 612106	10.5	-	-	
0	Horizontal Sling Kit 612110	53.5	-	-	
0	Trunnion Handling Fittings 612113	1.0	-	-	
0	Refrigeration Unit 612115	101.1	-	-	
1	Rack Cooling Unit 612XXX	50.5	12	242	
1	Cleaning Kit 612114	11.5	12	55	
0	Desiccant Drying Oven 614002	27.5	-	-	
1	Grounding/Bonding Tester 613039	31.0	12	149	
0	Cable Sets and Adapters	-	-	-	
1	Portable Leak Detector 612080	2.5	12	12	
0	Freon Servicer 612084	25.0	-	-	
0	Freon Leak Detector 612086	1.0	-	-	
0	Optical Alignment Kit 612040	6.0	-	-	
0	Transport Instrumentation 614XXX	20.0	-	-	
0	Operator's Console 612XXX	80.0	-	-	
0	Optical Bench Support Cart				
0	Inert Gas Cart				
0	FSS Holding Jig and Cover				
0	Broad Band Illuminator				
0	Antenna Support Cart				
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4-26

SD 78-SR-0009-2

Table 4-28. ATL GSE Requirements (Sheet 3 of 6)

Location Site #3 Option A-1					
Quantity	Equipment Name		Unit Cost (\$K)	Invlvm't Time(Days)	Prorated Cost/Flt(\$)
1	Double Rack Handling Kit	613050	9.0	34	123
1	Vertical Sling Kit	612006A	10.5	31	130
1	Feed Thru Prot. Covers	612008	3.0	26	31
1	Pallet Seg. Floor Covers	612010	3.5	31	43
1	Pallet Segment Support	612013	47.0	34	639
0	Rack/Floor Shipping Cover	612047	8.0	-	-
0	Rack/Floor Transport Platform	612048	1.0	-	-
0	Rack/Floor Support Braces	612049	2.5	-	-
1	Pallet Cover	612059	12.5	29	145
1	Pallet Platform	612060	24.0	29	278
1	Desiccant Canister Large	612067	11.5	29	134
1	Desiccant Canister Medium	612068	9.0	29	104
1	Active Environment Cart	612071A	33.0	29	383
1	Road Tiedown Kit	612106	10.5	29	122
1	Horizontal Sling Kit	612110	53.5	31	663
4	Trunnion Handling Fittings	612113	1.0	31	50
0	Refrigeration Unit	612115	101.1	-	-
1	Rack Cooling Unit	612XXX	50.5	23	465
1	Cleaning Kit	612114	11.5	23	106
1	Desiccant Drying Oven	614002	27.5	23	253
1	Grounding/Bonding Tester	613039	31.0	23	285
0	Cable Sets and Adapters		-	-	-
1	Portable Leak Detector	612080	2.5	23	23
0	Freon Servicer	612084	25.0	-	-
0	Freon Leak Detector	612086	1.0	-	-
1	Optical Alignment Kit	612040	6.0	23	55
1	Transport Instrumentation	614XXX	20.0	26	208
0	Operator's Console	612XXX	80.0	-	-
0	Optical Bench Support Cart				
0	Inert Gas Cart				
0	FSS Holding Jig and Cover				
0	Broad Band Illuminator				
0	Antenna Support Cart				
					4240

Table 4-28. ATL GSE Requirements (Sheet 4 of 6)

Location Lead Ctr Option B-4					
Quantity	Equipment Name		Unit Cost (\$K)	Invlvm't Time(Days)	Prorated Cost/Flt(\$)
0	Double Rack Handling Kit	613050	9.0	-	-
1	Vertical Sling Kit	612006A	10.5	36	151
1	Feed Thru Prot. Covers	612008	3.0	31	37
2	Pallet Seg. Floor Covers	612010	3.5	36	101
1	Pallet Segment Support	612013	47.0	39	733
1	Rack/Floor Shipping Cover	612047	8.0	34	109
1	Rack/Floor Transport Platform	612048	1.0	39	16
1	Rack/Floor Support Braces	612049	2.5	39	39
2	Pallet Cover	612059	12.5	34	170
2	Pallet Platform	612060	24.0	34	653
1	Desiccant Canister Large	612067	11.5	34	156
1	Desiccant Canister Medium	612068	9.0	34	122
2	Active Environment Cart	612071A	33.0	34	898
1	Road Tiedown Kit	612106	10.5	34	143
1	Horizontal Sling Kit	612110	53.5	36	770
4	Trunnion Handling Fittings	612113	1.0	36	58
1	Refrigeration Unit	612115	101.1	28	1131
1	Rack Cooling Unit	612XXX	50.5	28	566
1	Cleaning Kit	612114	11.5	28	129
1	Desiccant Drying Oven	614002	27.5	28	308
1	Grounding/Bonding Tester	613039	31.0	28	347
0	Cable Sets and Adapters		-	-	-
1	Portable Leak Detector	612080	2.5	28	28
1	Freon Servicer	612084	25.0	28	280
1	Freon Leak Detector	612086	1.0	28	11
1	Optical Alignment Kit	612040	6.0	28	67
1	Transport Instrumentation	614XXX	20.0	31	248
1	Operator's Console	612XXX	80.0	28	896
0	Optical Bench Support Cart				
0	Inert Gas Cart				
0	FSS Holding Jig and Cover				
0	Broad Band Illuminator				
0	Antenna Support Cart				
					8167

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Table 4-28. ATL GSE Requirements (Sheet 5 of 6)

Location: Lead Ctr Option B-5				
Quantity	Equipment Name	Unit Cost (\$K)	Invlvm't Time (Days)	Prorated Cost/Fit (\$)
0	Double Rack Handling Kit 613050	9.0	-	-
1	Vertical Sling Kit 612006A	10.5	36	151
1	Feed Thru Prot. Covers 612008	3.0	31	37
2	Pallet Seg. Floor Covers 612010	3.5	36	101
1	Pallet Segment Support 612013	47.0	39	733
1	Rack/Floor Shipping Cover 612047	8.0	34	109
1	Rack/Floor Transport Platform 612048	1.0	39	16
1	Rack/Floor Support Braces 612049	2.5	39	39
2	Pallet Cover 612059	12.5	34	170
2	Pallet Platform 612060	24.0	34	653
1	Desiccant Canister Large 612067	11.5	34	156
1	Desiccant Canister Medium 612068	9.0	34	122
2	Active Environment Cart 612071A	33.0	34	898
1	Road Tiedown Kit 612106	10.5	34	143
1	Horizontal Sling Kit 612110	53.5	36	770
4	Trunnion Handling Fittings 612113	1.0	36	58
1	Refrigeration Unit 612115	101.1	28	1131
1	Rack Cooling Unit 612XXX	50.5	28	566
1	Cleaning Kit 612114	11.5	28	129
1	Desiccant Drying Oven 614002	27.5	28	308
1	Grounding/Bonding Tester 613039	31.0	28	347
0	Cable Sets and Adapters	-	-	-
1	Portable Leak Detector 612080	2.5	28	28
1	Freon Servicer 612084	25.0	28	280
1	Freon Leak Detector 612086	1.0	28	11
1	Optical Alignment Kit 612040	6.0	28	67
1	Transport Instrumentation 614XXX	20.0	31	248
1	Operator's Console 612XXX	30.0	28	896
0	Optical Bench Support Cart			
0	Inert Gas Cart			
0	FSS Holding Jig and Cover			
0	Broad Band Illuminator			
0	Antenna Support Cart			
				8167

Table 4-28. ATL GSE Requirements (Sheet 6 of 6)

Location: KSC Option C-4				
Quantity	Equipment Name	Unit Cost (\$K)	Invlvm't Time (Days)	Prorated Cost/Fit (\$)
0	Double Rack Handling Kit 613050	9.0	-	-
1	Vertical Sling Kit 612006A	10.5	30	126
1	Feed Thru Prot. Covers 612008	3.0	25	30
2	Pallet Seg. Floor Covers 612010	3.5	30	42
1	Pallet Segment Support 612013	47.0	31	528
1	Rack/Floor Shipping Cover 612047	8.0	26	83
1	Rack/Floor Transport Platform 612048	1.0	31	12
1	Rack/Floor Support Braces 612049	2.5	31	31
2	Pallet Cover 612059	12.5	26	130
2	Pallet Platform 612060	24.0	26	250
1	Desiccant Canister Large 612067	11.5	26	120
1	Desiccant Canister Medium 612068	9.0	26	93
2	Active Environment Cart 612071A	33.0	26	343
1	Road Tiedown Kit 612106	10.5	26	109
1	Horizontal Sling Kit 612110	53.5	30	642
4	Trunnion Handling Fittings 612113	1.0	30	48
1	Refrigeration Unit 612115	101.1	24	970
1	Rack Cooling Unit 612XXX	50.5	24	485
1	Cleaning Kit 612114	11.5	24	110
1	Desiccant Drying Oven 614002	27.5	24	264
1	Grounding/Bonding Tester 613039	31.0	24	298
0	Cable Sets and Adapters	-	-	-
1	Portable Leak Detector 612080	2.5	24	24
1	Freon Servicer 612084	25.0	24	240
1	Freon Leak Detector 612086	1.0	24	10
1	Optical Alignment Kit 612040	6.0	24	58
1	Transport Instrumentation 614XXX	20.0	25	200
1	Operator's Console 612XXX	30.0	24	768
0	Optical Bench Support Cart			
0	Inert Gas Cart			
0	FSS Holding Jig and Cover			
0	Broad Band Illuminator			
0	Antenna Support Cart			
				6014

4-28

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Since the GSE under consideration is only that GSE required to support the Level IV operations, those activities associated with Level III/II integration through post-flight operations for each flight are not considered. For GSE the total involvement time consists of the total serial processing time from preparation of experiment and Spacelab equipment through the completion of the Level IV activities and the readiness of the payload to begin Level III (functional block 11) plus the Level IV de-integration operations (functional block 16) after the mission.

SPACELAB FLIGHT HARDWARE REQUIREMENTS

The Spacelab flight hardware requirements for each payload were determined by analyzing the total processing flow times of each option and determining the involvement time of each Spacelab Flight hardware end item. The determination of the Spacelab flight hardware requirements for each payload configuration is a constant. The real variable is the length of each processing flow. From the determination of total involvement time of the Spacelab flight hardware, a prorated cost per flight was established. The prorated cost per flight was defined by the following:

$$\text{Prorated Cost/Flight} = \frac{\text{Involvement Time (days)} \times \text{Unit Cost of Equip. (\$)} \times \text{Quantity}}{250 \text{ days} \times 10 \text{ yr. life}}$$

The Spacelab flight hardware items evaluated were each payloads requirements for:

- | | |
|------------------|-------------------------|
| • Racks (Expmt) | • Inverters |
| • Pallet Segment | • Freon Pumps |
| • RAU's | • Expmt Heat Exchangers |
| • EPDB's | • EPSP's |
| • ICS's | • Floor Segments |
| • Cold Plates | |
| • IPS | |
| • SIPS | |

The Spacelab flight hardware proration cost estimates for the four payloads and each applicable option are shown in Tables 4-29 through 4-32.

PAYLOAD COST SUMMARIES

These summaries have been developed, for each viable option of the four design reference missions, by an accumulation of the per flight costs in each of the four resource categories:

- | | |
|------------------|----------------------------|
| • Manpower | • GSE |
| • Transportation | • Spacelab Flight Hardware |

Table 4-29. Space Processing Flight Hardware Requirements

Quan	Equipment Name	Unit Cost (\$K)	Days Involvement (Days)	Prorated Cost/Flt (\$)
1	Processing Option A-1 PALLET (Incl: 1 RAU, 1 EPDB, 4 Cold Plates, 1 Inverter, 1 Freon Pump & Accum., 1 ICS, and 1 Exp. Heat Exchanger)	\$3,724.0	69.5	\$103,527
				\$103,527
1	Processing Option A-2 PALLET (Incl: 1 RAU, 1 EPDB, 4 Cold Plates, 1 Inverter, 1 Freon Pump & Accum., 1 ICS, and 1 Exp. Heat Exchanger)	\$3,724.0	69.5	\$103,527
				\$103,527
1	Processing Option B-1 PALLET (Incl: 1 RAU, 1 EPDB, 4 Cold Plates, 1 Inverter, 1 Freon Pump & Accum., 1 ICS, & 1 Exp. Heat Exchanger)	\$3,724.0	69.5	\$103,527
				\$103,527
1	Processing Option B-2 PALLET (Incl: 1 RAU, 1 EPDB, 4 Cold Plates, 1 Inverter, 1 Freon Pump & Accum., 1 ICS, & 1 Exp. Heat Exchanger)	\$3,724.0	69.5	\$103,527
				\$103,527
1	Processing Option B-4 PALLET (Incl: 1 RAU, 1 EPDB, 4 Cold Plates, 1 Inverter, 1 Freon Pump & Accum., 1 ICS, & 1 Exp. Heat Exchanger)	\$3,724.0	69.5	\$103,527
				\$103,527
1	Processing Option C-1 PALLET (Incl: 1 RAU, 1 EPDB, 4 Cold Plates, 1 Inverter, 1 Freon Pump & Accum., 1 ICS, & 1 Exp. Heat Exchanger)	\$3,724.0	61.5	\$91,610
				\$91,610
1	Processing Option C-2 PALLET (Incl: 1 RAU, 1 EPDB, 4 Cold Plates, 1 Inverter, 1 Freon Pump & Accum., 1 ICS, & 1 Exp. Heat Exchanger)	\$3,724.0	61.5	\$91,610
				\$91,610
1	Processing Option C-4 PALLET (Incl: 1 RAU, 1 EPDB, 4 Cold Plates, 1 Inverter, 1 Freon Pump & Accum., 1 ICS, & 1 Exp. Heat Exchanger)	\$3,724.0	61.5	\$91,610
				\$91,610

Table 4-30. Combined Astronomy Flight Hardware Requirements (Sheet 1 of 2)

Quan	Equipment Name	Unit Cost (\$K)	Days Involvement (Days)	Prorated Cost/Flt (\$)
1	Processing Option A-1 Fwd Mini-center PALLETS, Single 1 ea	3,022.0	58	\$ 70,110
1	(Incl: 1 Freon Pump, 3 Cold Plates, 2 RAU ⁺ , 1 EPDB, 1 ICS, & 1 Inverter)	668.0	58	15,498
1	SMALL INSTRUMENT POINTING SUBSYS(SIPS) *Incl 1-RAU at OAFD C&D Panel	1,500	58	34,800
				\$120,408
1	Processing Option A-1 Mid Mini-center PALLETS, Single 1 ea	3,022.0	61	\$ 73,737
1	(Incl: 1 Cold Plate, 1 EPDB, & 2 ICS)	121.0	61	2,952
1	PALLETS, Double 1 ea	6,044.0	61	147,474
1	(Incl: 1 Cold Plate, 1 RAU, 1 EPDB, 1 ICS)	261	61	6,368
1	INSTRUMENT POINTING SUBSYS (IPS)	10,000.0	61	244,000
				\$474,531
1	Processing Option A-1 Aft Mini-center PALLETS, Single 1 ea	3,022.0	54	65,275
1	(Incl: 1 Cold Plate, 1 RAU, 1 EPDB, 1 ICS)	261.0	54	5,638
				\$70,913
1	Processing Option A-2 Fwd Mini-center PALLETS, Single, 1 ea	3,022.0	64	\$77,363
1	(Incl: 1 Freon Pump, 3 Cold Plates, 2 RAU ⁺ , 1 EPDB, 1 ICS, & 1 Inverter)	668.0	64	17,101
1	SMALL INSTRUMENT POINTING SUBSYS(SIPS)	1,500.0	64	38,400
				\$132,864
1	Processing Option A-2 Mid Mini-center PALLETS, Single, 1 ea	3,022.0	78	94,286
1	(Incl: 1 Cold Plate, 1 EPDB, 2 ICS)	121.0	78	3,775
1	PALLETS, Double, 1 ea	6,044.0	78	188,573
1	(Incl: 1 Cold Plate, 1 RAU, 1 EPDB, 1 ICS)	261.0	78	8,143
1	INSTRUMENT POINTING SUBSYS (IPS)	10,000.0	78	312,000
				\$606,778
1	Processing Option A-2 Aft Mini-center PALLETS, Single 1 ea	3,022.0	71	85,825
1	(Incl: 1 Cold Plate, 1 RAU, 1 EPDB, 1 ICS)	261.0	71	7,412
				\$93,237

Table 4-30. Combined Astronomy Flight Hardware Requirements (Sheet 2 of 2)

Quan	Equipment Name	Unit Cost (\$K)	Days Involvement (Days)	Prorated Cost/Flt (\$)
1	Processing Option B-1 Lead Center			
1	PALLETS, Single, 3 ea	9,066.0	61	\$221,210
1	(Incl. 1 Freon Pump, 5 Cold Plates, 3 RAU, 3 EPDB, and 4 ICS)	950.0	61	23,180
1	PALLETS, Double, 1 ea	6,044.0	61	147,474
1	(Incl. 2 Cold Plates, 1 RAU, 1 EPDB, 1 ICS)	288.0	61	7,027
1	INSTRUMENT POINTING SUBSYS (IPS)	10,000.0	61	36,000
1	SMALL INSTRUMENT POINTING SUBSYS (SIPS)	1,500.0	61	244,000
				\$678,891
1	Processing Option B-2 Lead Center (Same as B-1 above)	27,848	78	\$868,858
1	Processing Option B-4 Lead Center (Same as B-1 above)	27,848	63	\$701,770
1	Processing Option C-1 KSC (Same as B-1 above)	27,848	53	\$590,378
1	Processing Option C-2 KSC (Same as B-1 above)	27,848	70	\$779,744
1	Processing Option C-4 KSC (Same as B-1 above)	27,848	55	\$612,656

Table 4-31. Life Sciences Flight Hardware Requirements (Sheet 1 of 2)

Quan	Equipment Name	Unit Cost (\$K)	Days Involvement (Days)	Prorated Cost/Flt (\$)
1	Processing Option A-1 Mini-center #1			
1	RACK, DOUBLE, 1 ea	434.0	60.2	\$10,500
1	(Incl. 1 EPSP, 1 RAU, and 1 CACB)			
1	FLOOR SEGMENT, Triple, 1 ea			
1	Processing Option A-1 Mini-center #2			
1	RACK, DOUBLE, 1 ea (Incl. 1 EPSP, 1 RAU, 1 ICS)	375.0	54.6	\$3,200
1	Processing Option A-1 Mini-center #3			
1	RACK, SINGLE, 2 ea (Incl. 2 EPSP)	358.0	52.6	7,500
1	Processing Option A-1 Mini-center #4			
1	RACK, DOUBLE, 1 ea (Incl. 1 EPSP, 1 ICS)	232.0	52.4	4,900
1	Processing Option A-1 Mini-center #5			
1	RACK, DOUBLE, 1 ea (Incl. 1 EPSP)	229.0	49.6	4,500
1	Processing Option A-1 Mini-center #6			
1	RACK, DOUBLE, 1 ea (Incl. 1 EPSP, 1 RAU)	372.0	53.6	8,000
1	Processing Option A-1 Mini-center #7			
1	RACK, DOUBLE, 1 ea (Incl. 1 EPSP, 1 ICS)	232.0	54.4	5,000
1	Processing Option A-1 Mini-center #8			
1	RACK, SINGLE, 2 ea (Incl. 2 EPSP, 1 CACB, 1 EPDB, 1 RAU)	651.0	68.4	17,800
1	FLOOR SEGMENT, Triple, 1 ea			
1	Payload Assembly			
1	FLOOR SEGMENT, Double, 1 ea	39.0	33.6	500
				\$66,900
1	Processing Option A-3 Mini-center #1			
1	RACK, DOUBLE, 1 ea	434.0	66.7	\$11,600
1	(Incl. 1 EPSP, 1 RAU, and 1 CACB)			
1	FLOOR SEGMENT, Triple, 1 ea			
1	Processing Option A-3 Mini-center #2			
1	RACK, DOUBLE, 1 ea (Incl. 1 EPSP, 1 RAU, 1 ICS)	375.0	61.1	9,200
1	Processing Option A-3 Mini-center #3			
1	RACK, SINGLE, 2 ea (Incl. 2 EPSP)	358.0	59.1	8,500
1	Processing Option A-3 Mini-center #4			
1	RACK, DOUBLE, 1 ea (Incl. 1 EPSP, 1 ICS)	232.0	58.9	5,500
1	Processing Option A-3 Mini-center #5			
1	RACK, DOUBLE, 1 ea (Incl. 1 EPSP)	229.0	56.1	5,100
1	Processing Option A-3 Mini-center #6			
1	RACK, DOUBLE, 1 ea (Incl. 1 EPSP, 1 RAU)	372.0	60.1	3,900
1	Processing Option A-3 Mini-center #7			
1	RACK, DOUBLE, 1 ea (Incl. 1 EPSP, 1 ICS)	232.0	60.9	5,700
1	Processing Option A-3 Mini-center #8			
1	RACK, SINGLE, 2 ea (Incl. 2 EPSP, 1 CACB, 1 EPDB, 1 RAU)	651.0	74.9	19,500
1	FLOOR SEGMENT, Triple, 1 ea			
1	Payload Assembly			
1	FLOOR SEGMENT, Double, 1 ea	39.0	33.6	500
				\$74,400

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Table 4-31. Life Sciences Flight Hardware Requirements (Sheet 2 of 2)

Quan	Equipment Name	Unit Cost (\$K)	Days Involvement (Days)	Prorated Cost/Flt (\$)
1	Processing Option B-1 RACKS, DOUBLE, 6 ea (Incl. 6 EPSP, 3 RAU, 1 EPDB, and 3 ICS)	1,900.0	70.2	553,352
1	RACKS, SINGLE, 4 ea (Incl 4 EPSP, 1 RAU, & 1 CACB)	862.0	70.2	24,205
1	FLOOR SEGMENT, Triple, 2 ea	118.0	70.2	3,313
1	FLOOR SEGMENT, Double, 1 ea	39.0	70.2	1,095
				<u>\$81,965</u>
1	Processing Option B-3 RACKS, DOUBLE, 6 ea (Incl 6 EPSP, 3 RAU, 1 CACB, 1 EPDB and 3 ICS)	1,900	77.7	59,052
1	RACKS, SINGLE, 4 ea (Incl. 4 EPSP, 1 RAU & 1 CACB)	862.0	77.7	26,791
1	FLOOR SEGMENT, Triple, 2 ea	118.0	77.7	3,667
1	FLOOR SEGMENT, Double, 1 ea	39.0	77.7	1,212
				<u>\$90,722</u>
1	Processing Option B-4 RACKS, DOUBLE, 6 ea (Incl 6 EPSP, 3 RAU, 1 CACB, 1 EPDB, and 3 ICS)	1,900	73.3	55,708
1	RACKS, SINGLE, 4 ea (Incl 4 EPSP, 1 RAU, 1 CACB)	862.0	73.3	25,274
1	FLOOR SEGMENT, Triple, 2 ea	118.0	73.3	3,460
1	FLOOR SEGMENT, Double, 1 ea	39.0	73.3	1,143
				<u>\$85,585</u>
1	Processing Option B-5 RACKS, DOUBLE, 6 ea (Incl 6 EPSP, 3 RAU, 1 CACB, 1 EPDB, and 3 ICS)	1,900	77.3	558,748
1	RACKS, SINGLE, 4 ea (Incl 4 EPSP, 1 RAU & 1 CACB)	862.0	77.3	26,653
1	FLOOR SEGMENT, Triple, 2 ea	118.0	77.3	3,649
1	FLOOR SEGMENT, Double, 1 ea	39.0	77.3	1,206
				<u>\$90,255</u>
1	Processing Option C-1 RACKS, DOUBLE, 6 ea (Incl 6 EPSP, 3 RAU, 1 CACB, 1 EPDB, and 3 ICS)	1,900	62.2	547,272
1	RACKS, SINGLE, 4 ea (Incl 4 EPSP, 1 RAU & 1 CACB)	862.0	62.2	21,447
1	FLOOR SEGMENT, Triple, 2 ea	118.0	62.2	2,936
1	FLOOR SEGMENT, Double, 1 ea	39.0	62.2	970
				<u>\$72,625</u>
1	Processing Option C-3 RACKS, DOUBLE, 6 ea (Incl 6 EPSP, 3 RAU, 1 CACB, 1 EPDB, and 3 ICS)	1,900	67.7	551,452
1	RACKS, SINGLE, 4 ea (Incl 4 EPSP, 1 RAU & 1 CACB)	862.0	67.7	23,343
1	FLOOR SEGMENT, Triple, 2 ea	118.0	67.7	3,195
1	FLOOR SEGMENT, Double, 1 ea	39.0	67.7	1,056
				<u>\$79,047</u>
1	Processing Option C-4 RACKS, DOUBLE, 6 ea (Incl. 6 EPSP, 3 RAU, 1 CACB, 1 EPDB, and 3 ICS)	1,900	65.3	549,628
1	RACKS, SINGLE, 4 ea (Incl 4 EPSP, 1 RAU & 1 CACB)	862.0	65.3	22,515
1	FLOOR SEGMENT, Triple, 2 ea	118.0	65.3	3,082
1	FLOOR SEGMENT, Double, 1 ea	39.0	65.3	1,019
				<u>\$76,244</u>

Table 4-32. ATL Spacelab Flight Hardware Requirements (Sheet 1 of 2)

Quan	Equipment Name	Unit Cost (\$K)	Days Involvement (Days)	Prorated Cost/Flt (\$)
1	Processing Option A-1 RACKS 5, 6, & Floor	703.0	70	19,684
1	PALLET #1 (Incl RAU, ICS, EPDB, Cold Plates)	3,418.0	70	95,704
1	RACK 4 (Double)	372.0	73	10,862
1	PALLET #2 (Incl EPDB, Cold Plates)	3,137.0	73	92,389
1	RACK 3	372.0	56	8,333
				<u>\$226,972</u>
1	Processing Option A-3 RACKS 5, 6 & Floor	703.0	75	21,040
1	PALLET #1 (Incl RAU, ICS, EPDB, Cold Plates)	3,418.0	75	102,540
1	RACK 4 (Double)	372.0	78	11,606
1	PALLET #2 (Incl EPDB, Cold Plates)	3,137.0	78	98,717
1	RACK 3	372.0	61	9,077
				<u>\$243,030</u>
1	Processing Option B-1 RACKS 5, 6, & Floor	703.0	76	21,371
1	PALLET #1 (Incl RAU, ICS, EPDB, Cold Plates)	3,418.0	76	103,907
1	RACK 4 (Double)	372.0	76	11,309
1	PALLET #2 (Incl EPDB, Cold Plates)	3,137.0	76	95,365
1	RACK 3	372.0	76	11,309
				<u>\$243,261</u>
1	Processing Option B-3 RACKS 5, 6, & Floor	703.0	80	22,496
1	PALLET #1 (Incl RAU, ICS, EPDB, Cold Plates)	3,418.0	80	109,376
1	RACK 4 (Double)	372.0	80	11,904
1	PALLET #2 (Incl EPDB, Cold Plates)	3,137.0	80	100,384
1	RACK 3	372.0	80	11,904
				<u>\$256,064</u>
1	Processing Option B-4 RACKS 5, 6, & Floor	703.0	80	22,496
1	PALLET #1 (Incl RAU, ICS, EPDB, Cold Plates)	3,418.0	80	109,376
1	RACK 4 (Double)	372.0	80	11,904
1	PALLET #2 (Incl EPDB, Cold Plates)	3,137.0	80	100,384
1	RACK 3	372.0	80	11,904
				<u>\$256,064</u>



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Table 4-32. ATL Spacelab Flight Hardware Requirements (Sheet 2 of 2)

Quan	Equipment Name	Unit Cost (\$K)	Days Involvement (Days)	Prorated Cost/Flt (\$)
1	Processing Option C-1	703.0	68	21,371
1	RACKS 5, 6, & Floor	703.0	68	\$ 21,371
1	PALLET #1 (Incl RAU, ICS, EPDB, Cold Plates)	3,418.0	68	103,907
1	RACK 4 (Double)	372.0	68	10,108
1	PALLET #2 (Incl EPDB, Cold Plates)	3,137.0	68	85,236
1	RACK 3	372	68	10,108
				<u>\$218,388</u>
1	Processing C-3			
1	RACKS 5, 6 & Floor	703.0	72	22,496
1	PALLET #1 (Incl RAU, ICS, EPDB, Cold Plates)	3,418.0	72	109,376
1	RACK 4 (Double)	372.0	72	10,714
1	PALLET #2 (Incl EPDB, Cold Plates)	3,137.0	72	90,346
1	RACK 3	372.0	72	10,714
				<u>\$231,235</u>
1	Processing C-4			
1	RACKS 5, 6 & Floor	703.0	72	22,496
1	PALLET #1 (Incl RAU, ICS, EPDB, Cold Plates)	3,418.0	72	109,376
1	RACK 4 (Double)	372.0	72	10,714
1	PALLET #2 (Incl EPDB, Cold Plates)	3,137.0	72	90,346
1	RACK 3	372.0	72	10,714
				<u>\$231,235</u>



It should be noted that these following costs are prorated per flight costs and are representative of the major groundrules and guidelines established in the previous sections of this volume. They are intended to provide a reference for the comparison of the 12 major processing options being analyzed as a part of this study. The programmatic cost summaries of these four payloads is discussed in detail in Volume III Optimizations and Programmatic.

Space Processing Ground Processing Cost Summary

The ground processing costs (per mission) for the Space Processing payload (not including KSC operational costs) from the initiation of Level IV processing through post-flight deintegration are summarized in Table 4-33, as "Total Costs Per Flight".

The manpower difference, although slight, reflects the host center support variations. This in turn is also reflected in TDY estimates. Transport and hardware proration estimates for the distributed (A-X) and centralized (B-X) options are identical because only one pallet segment is involved. The involvement time for the KSC (C-X) options are less because of shorter transportation times. Thus, prorated hardware costs are also correspondingly less.

Table 4-33. Space Processing Ground Processing Costs
(Costs in \$K)

Option	Cost Category					Total Costs Per Flight
	M/P	TDY	XPort	GSE	Flt Hdwe	
A1	119	21	15	6	104	265
A2	123	21	15	6	104	269
B1	124	28	15	6	104	277
B2	128	28	15	6	104	281
B4	128	28	15	6	104	281
C1	130	43	4	4	92	273
C2	134	44	4	4	92	277
C4	134	44	4	4	92	277

Combined Astronomy Ground Processing Cost Summary

The ground processing costs for the Combined Astronomy payload (not including KSC operational costs) from initiation of level IV integration through post flight deintegration are summarized in Table 4-34 as "Total Costs Per Flight". The cost differences between concepts and between options is relatively minor. Manpower estimates between comparable options are essentially the same as the variation is due almost entirely to variations in host center support. The differences between the dash options (e.g. A-1, B-1, C-1) and the other options is because of the lack of pre III/II combined payload checkout. Note that variations in TDY and transportation costs between comparable options of the concepts tend to off-set each other.

Pro-rated hardware costs are proportional to the involvement times. Prorated GSE costs do not appear to be a significant recurring cost factor. Variations between the distributed site (A-X) options and the other options reflect the requirement for multiple GSE end items to support distributed site activities. The primary cost factor is obviously the flight hardware proration. Differences between comparable options and concepts are primarily due to the transportation time differences.

Table 4-34. Combined Astronomy Ground Processing Cost Summary
(Costs in \$K)

Option	Cost Category					Total Costs Per Flight
	M/P	TDY	Xport	GSE	Flt Hdwr	
A-1	167	20	42	14	666	909
A-2	207	32	45	16	833	1133
B-1	174	26	22	8	679	909
B-2	201	35	22	12	869	1139
B-4	170	37	22	10	702	941
C-1	180	62	3	5	509	840
C-2	213	67	3	9	780	1072
C-4	176	60	3	7	613	859



Life Science Ground Processing Cost Summary

The compilation of similar ground processing costs (illustrated in Table 4-35) for the Life Science payload indicates that manpower costs for the multiple (8" mini-centers) distributed site approach will be higher than if individual experiments were integrated at a centralized site. Improved efficiency in hands-on activities can be achieved at a centralized site for rack/floor mounted equipment. Additional efficiency improvement can be achieved if a combined payload integration approach (B-4, B-5, C-4) is used. The inverse relationship of TDY and transportation costs is again evident.

GSE prorated costs are relatively low. Multiple GSE equipment requirements are reflected in the A-X options. Flight hardware prorations again reflect variations in involvement times.

Table 4-35. Life Science Ground Processing Costs
(Costs in \$K)

Option	Cost Category					Total Costs Per Flight
	M/P	TDY	Xport	GSE	Flt Hdwr	
A-1	193	22	70	17	67	369
A-3	212	31	70	19	74	406
B-1	163	34	17	6	82	302
B-3	178	36	17	7	91	329
B-4	158	35	17	8	86	304
B-5	169	33	17	9	90	318
C-1	169	53	3	5	73	303
C-3	187	57	3	6	79	332
C-4	168	56	3	6	76	309

ATL Ground Processing Cost Summary

The Advanced Technology Laboratory payload cost compilation (shown in Table 4-36) indicates characteristics very similar to the Life Science payload compilation. Efficiencies can be achieved by centralizing integration activities, and further improved by integrating at the combined payload level, which for example requires only one GSE connection/disconnection versus multiple connections with individual experiment verifications. TDY, transportation, and hardware proration characteristics also parallel the Life Science payload characteristics.

Table 4-36. ATL Ground Processing Costs

Option	Cost Category					Total Costs Per Flight
	M/P	TDY	Xport	GSE	Flt Hdwe	
A-1	194	31	34	10	227	496
A-3	224	41	34	10	243	552
B-1	200	39	14	7	243	503
B-3	209	40	14	8	256	527
B-4	202	49	14	8	256	529
B-5	212	50	14	8	268	552
C-1	206	58	3	5	218	490
C-3	223	60	3	6	231	523
C-4	209	76	3	6	231	525

Flight Hardware Involvement Time Summary

The summary of flight hardware involvement times (working days) reflects the differences in transportation times between KSC options and distributed site/lead center options, additional serial processing time for pre-Level III/II combined payload checkout, and the differences in efficiencies between individual experiment integration and combined payload integration. See Table 4-37. The involvement time (working days) span between options that include the same level of checkout (Level III/II checkout versus pre-Level III/II checkout) are all less than two weeks. The pre-Level III/II checkout adds about two additional weeks to the flows.

Table 4-37. Flight Hardware Involvement Time Summary (Working Days)

Payload Working Days \ Option	A-1	A-2	A-3	B-1	B-2	B-3	B-4	B-5	C-1	C-2	C-3	C-4
COMB. ASTRON. FWD	58	64										
MID	61	78										
AFT	54	71										
Lead Center				61	78		63		53	70		55
KSC												
SPACE PROCESSING	70	70		70	70		70		62	62		62
ATL- Mini Site 1	70		75									
Mini Site 2	56		61									
Mini Site 3	73		78									
Lead Center				76		80	80	83				
KSC									68		72	72
LIFE SCIENCE Mini Site 1	60		67									
Mini Site 2	55		61									
Mini Site 3	53		59									
Mini Site 4	52		59									
Mini Site 5	50		56									
Mini Site 6	54		60									
Mini Site 7	54		61									
Mini Site 8	68		75									
Lead Center				70		78	73	77				
KSC									62		68	65

4-38

SD 78-SR-0009-2

APPENDIX



ACRONYMS AND ABBREVIATIONS LIST

Å	Angstrom	EGRET	Explore Gamma Ray Experiment Telescope
AAM	Ambient Air Monitor	EI	End Item
AC	Alternate Current	EKG	Electrocardiogram
ACCEL	Acceleration	EL	Electrolite
AFD	Aft Flight Deck	EMI	Electromagnetic Interference
AMP	Amplifier	EOG	Oculographic
ANAL	Analysis	EPDB	Experiment Power Distribution Box
ARC	Ames Research Center	EPSP	Experiment Power Switching Panel
ASSY	Assembly	ES	Electrical/Environment System
ATL	Advanced Technology Laboratory	EXP	Experiment
ATT	Attitude	EXPMT	Experiment
AVG	Average		
		FACL	Facility
B/L	Baseline	FILT	Filter
BLKHD	Bulkhead	FLT	Flight
BRKT	Bracket	FOV	Field of View
BSHF	Bio Science Holding Facility	FSS	Flight Support System
BUP	Buildup	FSS	Forward Support Structure
		FT	Foot, Feet
C	Centigrade	FUNCT	Function
CA	Combined Astronomy	FURN	Furnish
CACB	Center Aisle Connector Bracket	FWD	Forward
CB	Canister Bracket	FZR	Freezer
CCTV	Closed Circuit Television		
C/D	Controls/Displays	g	Gravity
CDMS	Command and Data Management System	GE	General Electric
cg	Center of Gravity	GN ₂	Gaseous Nitrogen
CITE	Cargo Interface Test Equipment	GPR	Ground Processing Requirements
CM	Centimeter	GSE	Ground Support Equipment
CMD	Command	GSR	Ground Support Requirements
C/O	Checkout		
CNTR	Control		
COAX	Coaxial		
CONN	Connector	HDWE	Hardware
CORE	Common Operational Research Equipment	HDRM	High Data Rate Multiplexer
CPU	Control Processing Unit	HE	Heat Exchanger
CRT	Cathode Ray Tube	He	Helium
CRYO	Cryogenics	HF	Holding Facility
CS	Command/Control System	Hr	Hour
CTRL	Control	HV	High Voltage
C&W	Caution and Warning	Hz	Hertz
Dbl	Double	ICRS	Intercomm Remote Station
DC	Direct Current	IMU	Inertial Measurement Unit
DDU	Data Display Unit	In	Inch
DED	Dedicated	IND	Independent
DEMOD	Demodulator	INT	Integrated
DEP	Dependent	INVERT	Inverter
DFP	Dedicated Freon Pump	INSTAL	Installation
DIA	Diameter	INV/V	Involvement
DIFFER	Differential	IR	Infrared
DIST	Distribution	IRU	Inertial Reference Unit
DWG	Drawing	I/O	Input/Output
DYN	Dynamics	IPS	Instrument Pointing System
		I/S	Interconnect Station
E	Engineer	IVT	Intraventricular
ECG	Electrocardiogram		
ECS	Environment Control System	JC	Jettison Cable
EDP	Experiment Definition Package	JSC	Johnson Spaceflight Center



K	Kelvin	SC	Signal Cable
Kg.	Kilogram	SCINT	Scintillator
KSC	Kennedy Spaceflight Center	SEG	Segment
		SHe	Super Critical Helium
LBNP	Lower Body Negative Pressure	SIG	Signal
LG	Large	SIPS	Small Instrument Pointing System
LGHE	Liquid/Gas Heat Exchanger	SIRTF	Shuttle Infrared Telescope Facility
LHe	Liquid Helium	S/L	Spacelab
LN2	Liquid Nitrogen	SP	Space Processing
L/S	Life Science	SPAR	Space Processing Application Rocket
		SPECT	Spectrometer
m	Meter	SSUS	Solid Spinning Upper Stage
MEAS	Measure	STBD	Starboard
MECH	Mechanism, Mechanical	STS	Space Transportation System
MEGRD	Medium Energy Gamma Ray Detector	SUB	Substitute
MET	Metered	SURV	Survey
Mev	Million Electron Volts		
MIC	Multiple Instrument Compartment	T	Technician
MISC	Miscellaneous	TDY	Temporary Duty
mm	Millimeter	TELE	Telescope
MOD	Module	TLM	Telemetry
M/P, MP	Manpower	TRANS	Transportation
MPF	Multipurpose Furnace		
MS	Mass Spectrometer	UV	Ultraviolet
MSS	Mission Specialist Station		
MTRS	Meters	VERIF	Verify, Verification
		VAC	Voltage Alternating Current
OAF	Orbiter Aft Flight	VDC	Voltage Direct Current
O&C	Operations and Checkout		
OEM	Orbital Environment Monitor	XMTR	Transmitter
OFLA	Off-line Assembly	XPORT	Transport
ONLA	On-line Assembly		
OPF	Orbiter Processing Facility		
OPS	Operations		
OSC	Oscilloscope		
OSCILL	Oscilloscope		
PC	Power Cable		
PDB	Power Distribution Box		
PI	Principal Investigator		
P/L	Payload		
PMT	Photomultiplier Tube		
PNL	Panel		
POS	Position		
PSS	Payload Special Station		
PWR	Power		
RAD	Radius		
RAU	Remote Acquisition Unit		
RBC	Red Blood Cell		
RCS	Reaction Control System		
RCVR	Receiver		
REC	Recorder		
Red	Reduction		
RESPIR	Respiration		
r.f.	Radio Frequency		
R.O.	Read Out		